LINGUISTIC AND PERCEPTUAL CONSTRAINTS ON SCANNING STRATEGIES: SOME DEVELOPMENTAL STUDIES

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I declare that this thesis has been composed by myself and that the work reported in it is my own.

No part has been submitted in support for another degree or qualification of this or any other University or Institute of Learning.

L. Hall.

Lesley C. Hall

To all the children with whom I collaborated
in playing "the games", whose as yet unblighted
spirit of enquiry renewed and sustained my own.

ABSTRACT

The main studies reported in this thesis were concerned to study the development of the child's ability to carry out an efficient visual search of a pictorial array in order to make judgements about the appropriacy of a previously presented linguistic description of the same array. By varying the linguistic descriptions and the physical arrangements of the arrays and controlling the amount of information already available to the child, it was hoped to discover something of the way children's perceptual, cognitive and linguistic abilities interacted to provide them with their conception of the world. Preschool children from four years onwards, as well as schoolchildren, teenagers and adults were used as subjects in these studies.

In the experimental technique used in most of the visual search studies, a statement was spoken to the subject concerning a pictorial array yet to be seen. When the array had been presented, the subject's task was to look at it in order to ascertain as quickly as possible whether the statement was a true or false description of the array. In several subsidiary studies the subject was given an instruction by the experimenter concerning the array which he was to search in order to tell the experimenter something about it. The subject's eye movements were recorded from the time of presentation of the array by means of a telescopic lens and a video system. The pictures composing the array were sufficiently disparate to require

gross eye movements in order for the array to be scanned. By inspection of the television record it was possible to measure various aspects of the subject's visual search. These measures, together with the subject's actual judgement or answer and the time taken to make the decision, were examined in order to gauge something of the subject's understanding of the statement, his method of searching the array for the information needed and the processing of that information in order to make the judgement.

Other studies which did not directly examine visual search were carried out to supplement and clarify some of the findings of the main studies. These too were concerned with the directive function of a linguistically mediated task.

The studies concerned with directly measuring visual search sought to do so within the context of the following range of topics. One study looked at the performance of subjects while judging sentences concerned with the spatial prepositions "at the top of" and "at the bottom of", while another study used sentences describing the arrays in terms of "in front of" and "behind". These studies investigated the directive force of the task and language in overcoming any tendencies to make either horizontal or vertical eye movements in certain directions according to perceptual constraints or habitual biases, rather than according to the demands of the task. With respect to the Top/Bottom Studies it was found that the task constraints were sufficient to overcome any habitual tendency to scan the top of the array before the bottom or vice versa, but were not sufficient, until adulthood, to overcome the tendency to fixate any location defined by the presence of a picture rather than one which was only linguistically defined. Nor were the constraints sufficient, until the teenage years, to enable the subjects to ignore the pictures irrelevant to the purpose of the task. The In Front of/ Behind Study tentatively indicated that once relevant criteria for a judgement were adopted by the subjects, they were more or less able to direct their first eye movements according to the demands of the task.

A further study was concerned, not to vary the meaning of the sentences, but rather to vary the form in which a given message was expressed, by looking at a subject's performance while he judged active and passive sentences. Associated with this study were several smaller studies which were concerned to explicate the ability of subjects to make horizontal eye movements in whichever direction was appropriate. The appropriate direction varied depending on whether pictures were to be related in ways which involved the operation of implicit spatial constraints such as occurred with verbs like "chase", "follow" or "look at". The sentence verification studies confirmed the findings of the Top/Bottom Studies that the absolute location of pictures did not influence the initial search pattern but that for the younger children the presence of irrelevant pictures proved to be distracting. The fact that this distraction acted selectively according to the truth value of the sentence revealed some fascinating insights about which aspects of the world subjects seek to characterize so as to match a sentence description against an array description or so as to directly map the sentence onto the array in terms of the relationship existing between two relevant pictures. Whereas teenage and adult subjects were more able to characterize the array or map the sentence directly onto the array in terms of the relationship existing between two relevant pictures, younger subjects preferred to characterize the array in terms of the pictures mentioned in the sentences rather than the specified relationship. Moreover, the voice of the sentence was also found to influence the way the subjects searched the arrays, indicating that the subjects were either trying to describe the array with the same order of constituents as in the sentence or else they were mapping the sentence onto the array in the same order as that in which the sentence was presented.

While all the previous studies had been concerned with the ability of subjects to make selective searches, the final eye movement study looked at the ability of subjects to make both exhaustive and selective searches as these were necessary in order to verify true and false sentences containing the affirmative and negative quantifiers "all"/"every" and "no"/"none". This study showed that for pre-school children the search pattern was independent of the judgement, for school children the task constrained the subject to search for the necessary information but not to make selective searches where these were appropriate. It was only the adults who were able to make judgements on the basis of the most efficient search pattern, be it exhaustive or selective. The pre-school subjects' comprehension of negative sentences was further investigated in several studies, the findings from which suggested that the way young subjects code sentences and arrays and try to match the encoded representations, affects their performance when verifying negative sentences but not when having to take account of negative information in other ways.

As well as permitting a more critical assessment of various models of sentence verification processing and of hypotheses about the important aspects of development than has been offered hitherto, the studies provided evidence about the stages involved in the organization and establishment of voluntary control of eye movements. The development of the organizational processes seems to involve a series of steps whereby changes in the subject's knowledge of the world, changes in the way that knowledge is used to search the world, and changes in the way new information is processed, all enable the subject to come to anticipate and control operations of inhibition or sustained directed activity in ways that are appropriate within the framework of ongoing purposive visual activities.

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CHAPTER 1

Scope of the Problems Posed by a Consideration of the Development of Scanning Strategies

1.1 The Importance of Scanning Strategies for Development. One of the most useful ways of characterizing the overall development of humans from infancy to adulthood is to emphasize the increasing selectivity, specificity and discrimination of which each individual is capable in his cognitive perceptual and physical activities. E.Gibson (1969) for one argues that these trends lead to the optimization of attention and increasing economy of information pick-up in perceptual development. Hochberg (1968) is in agreement with this viewpoint since he believes that the important changes resulting from perceptual learning involve where a person looks and how he remembers, rather than what is seen in any momentary glance. This view is supported by Haith's (1971) review of studies of young children's information processing during tachistoscopic presentation of stimuli. This matter is given a fuller treatment in Chapter 2, but basically the studies indicate that children as young as five use fairly rapid and efficient information processes with single and multiple stimuli available for a single fixation, provided that a strategy for dealing with the stimuli is imposed within 150 milliseconds of the offset of the visual array.

Thus it may be argued that changes in perceptual performance mainly occur by means of changes in the individual's deployment of attention through eye movements and by changes in the way information from each fixation is stored and integrated into a schematic record. It is with this aspect of development that the thesis is concerned, with measures of eye movements being used to provide some insight into which factors are important for the development of scanning strategies. The justification for using these measures rests on the structure of the human visual system which requires the viewer to move his eyes in very fast jumps or rotations of the eyes called saccades, so that different small areas of the world form sequential images on that part of the retina known as the fovea. The fovea is a small, nearly circular area of the retina which contains a high concentration of cone cells and allows for a high degree of acuity. Ditchburn (1973) provies a description of the various regions of the retina centring around the fovea but admits that precise definition is not possible. An area labelled the foveola, where cones are most closely packed and visual acuity is highest, covering 20' of the visual field, is sometimes distinguished from the foveal region which covers less than 2^{o} of the visual field. Even within the fovea there is considerable variation in visual acuity and intercone distance. A parafoveal region within which the concentration of cone cells decreases markedly as that of rod cells increase, extends out to cover an area of the visual world about 10^{o} in diameter. The remaining region is called the periphery and contains the greatest number of rod cells which detect movement and allow for vision at low degrees of illumination.

That time during which the image of a small part of the world falls on the fovea without interruption apart from minor drifts and tremors about the optical axis, is known as a fixation. With adults, approximately three, and no more than four fixations can be made in a second, although the precise number can vary depending on the complexity of the information being processed during each fixation. Only a small percentage of an adult's total viewing time is taken up with moving the eye so that the image of a new area of the visual field falls on the fovea. During these movements, known as saccades, visual sensitivity is reduced, although Peace and Porter (1970) argue that the decrease in detection performance in the temporal vicinity of voluntary saccades is insufficient to account for the phenomenal lack of blurring of the visual environment when voluntary saccades are performed. Latour (1966) and Volkmann et al (1968) suggest that a central inhibitory effect is responsible for reducing the magnitude of the visual signal during a saccade. But whatever the mechanism, there seems to be little evidence for the processing of any information arriving at the eye during a saccadic eye movement and most researchers studying visual perceptual processing assume that recognition processes operate solely on the intake made available during eye pauses or fixations.

Thus precise information about parts of the world requires foveal vision while information about the rest of the world comes from peripheral vision which Trevarthen (1968) regards as the basis of "ambient" vision, providing the main "temporo-spatial frame or context" for "focal" vision. In order to construct a stable picture of the world, ordered eye movements are required so as to synthesize ambient and focal vision. Trevarthen (1973, p.4) describes the two main strategies by which eye movements can be ordered. The first of these is described as a "finding" or "attracted" scan, whereby each successive focussing on the visual field is determined by reactions to the "appearance of a concentration or source of information in a place in the off-centre part of the field." The second strategy labelled as a "seeking or projected" scan "invents foci for fixation according to the structure of a mental image which may not be supported by appropriate stimuli anywhere in the present peripheral field." The first strategy of attracted scan would seem to involve at least partial programming of each successive saccade during the prior fixation as described by Jeannerod (1972). He believes that during any fixation the foveal information is analysed in detail and the extra-foveal information, although gross and imprecise is used for making assumptions. Thus a part of the fixation is devoted to the evaluation and selection of a given portion of the extra-foveal map. He argues that since tachistoscopic investivations indicate that foveal information can be processed very rapidly, the major part of fixation time is devoted to sampling and decision making. The second strategy of projected scan would not require this sort of sampling or decision making since this would be determined by the overriding cognitive plans.

The ability of a viewer to employ whichever strategy is most suitable to a given situation, be it one requiring the accommodation to external reality or one requiring the assimilation of reality, has important implications for his capacity to operate in a voluntary and efficient manner in and on the world. Trevarthen (1973 p.4) puts the case very well when he says:

"More 'true' or complete perception of the structures and identities of external objects in space, and more efficient voluntary-motor strategies for operating on objects, require cognitive rules which lift the determination of action out of the simple, immediate sensory-motor mechanisms which regulate the automatic equilibrations of posture and orientation in egocentric space."

1.2. <u>Overview of Chapter</u>. The chapter has so far been concerned to declare and justify the aspect of child development with which it deals, namely the development of active selective perception. In order to investigate this area it is necessary to ascertain as many as possible of the factors playing a part in influencing such development. From the point of view of this thesis the most important of these include the cognitive constraints of the situation in which a person is placed and the characteristics of the stimulus materials with which he must deal. It is with these factors that the review which follows will deal. Other important factors such as physiological constraints on visual acuity, the size of the functional peripheral field, and the latency of the ocular-motor movements used to re-orient the eye from one part of the visual field to the other, also need to be borne in mind. So does the related matter of pre-dispositions to search the visual field in certain ways, regardless of the task or stimulus materials. Discussion of these factors will be deferred until Chapter 2 when the evidence arising from a review of the relevant literature will be used to guide the construction of the task used for most of the experimental studies.

The review will cover the pertinent infant, child and adult literature which deals with perception within the stationary head field or in other words the eye-field. The rest of the chapter proceeds as follows: the infant literature will be surveyed first and then a diversion will be made into the areas of linguistic and cognitive development after which the child and adult literature will be dealt with. The diversion was necessitated by the fact that most of the studies on visual search, which use subjects with some facility with language, have been carried out within a partially linguistic context. In order to estimate the extent to which the linguistic context gave subjects the opportunity to use cognitive constraints to organize their scanning, it was important to spell out the relationship between language and cognition at various stages throughout development.

With that done, the chapter returns to a review of those studies using eye movement measures to investigate adults' and children's scanning strategies. The adult studies are reviewed first so as to provide some indication of the level of mature functioning, both in terms of the efficient direction of a sequence of eye movements and the ability to extract information efficiently during each fixation.

The judgment made of the scope and coherency of the present state of knowledge will indicate the motivation for the studies which follow, designed as they were to fill some of the gaps in our knowledge of children's perceptual and cognitive abilities.

1.3. Scanning Strategies in Infancy. According to Trevarthen (1973) the development of active selective perception as well as precise voluntary action emerges out of an already established ability to co-ordinate body, head and eye movements which provides a basis for interrogating the world. Trevarthen reports that from birth the infant can make spontaneous conjugate saccades at the same rate and with the same accuracy as adults. However the amount of information extracted from the environment during the fixations is limited by the fact that it may take several months before the cone system, as well as lens accommodation and pupillary adjustments, are sufficiently mature to allow detailed feature discrimination. The rod system however is nearly fully functional at birth. Both these aspects of perceptual development come to be co-ordinated within the already established hierarchy of saccadic scanning so that the gaze can be directed systematically or preferentially.

Salapatek (1973) reports a study with Aslin, in which they examined the sensitivity of one- and two-month old infants to targets introduced into the peripheral field when the infant was either looking at a target or nothing in the central field. They found that the probability of movement, as measured by electro-ocularography, was greater the nearer the introduced object came to the centre of the infant's visual field and the fewer the number of other objects in the field. The ocular-motor latencies were variable but at their shortest time of about 200-250 milliseconds, they approached adults' standards. Most interestingly, it was found that the infant did not localize a peripheral target by a single ballistic saccade as does the adult but by means of a series of more closely appromimating saccades. Thus the very young infant can be observed to make at least one "attracted" scan even though it is uncertainly and slowly executed within quite a limited area.

Harris and MacFarlane (1974) have been able to shed some light on the precise limitations of the peripheral vision of neonates and 7-week old infants in a situation where a light was introduced in the peripheral field both when a central stimulus light was being fixated and when no stimulus was being fixated. They report that when no stimulus was being fixated the neonate would orient towards the peripheral light at up to 25° from the midline, but when a central stimulus was fixated the functional peripheral field was reduced to approximately 15° or less. The 7-week old infant was no more likely to re-orient from the central stimulus over a wider peripheral field but was able to re-orient up to 30°-38° from the midline when not fixating any stimulus. Harris and MacFarlane were unable to make any conclusions as to whether the restricted gaze patterns reflected a limitation on the actual detection of peripheral information or a failure to make use of otherwise adequate peripheral sensitivity to direct eye movements.

The ability of new-born infants to orient to and inspect simple geometric forms, such as a triangle, has been investigated by Salapatek and his co-workers in a series of studies using corneal reflection photography to record eye movements and fixations. Salapatek and Kessen (1966) and Salapatek (1968) found that when presented with a patternless visual field, infants of 0 to 1 weeks would make large scans across the field with the fixations not being concentrated in any particular area. However when a triangle was introduced into the field they would orient to it with central vision but would only attend to a limited portion of the figure. Certain features of the figure, in particular one of the vertices, would receive more fixations than other areas. Four- to six-week old infants showed the same single angle selection although by 8 to 10 weeks most infants showed a shift to multiple feature selection (Salapatek, 1969). This limited feature selection was found even with repeated exposures of the triangle and for varying durations of the exposure, although Salapatek and Kessen (1973) found that beyond this basic characteristic response there was considerable variability between and within subjects in their general style of scanning.

Thus it would seem that the ability of the youngest of viewers to make "attracted" scans over more than a small area is very limited indeed. One possible explanation would attribute this failure to orient to information falling on the parafoveal and more peripheral regions of the retina as arising more from the slow processing of foveal information than from a lack of information from the periphery. This seems likely since peripheral information was presumably sufficient to direct initial eye movements to a high information area such as a vertex. Moreover, as Trevarthen points out, the peripheral regions are more developed at birth than the foveal.

These basic conclusions regarding part/whole and angle selection seemed to hold up and were even strengthened in some cases when Salapatek subjected his data to reanalysis in order to take into account the systematic error inherent in the corneal photographic technique as described by Slater and

Findlay (1972a). They made several pertinent criticisms of the limitations of the technique, pointing out that their calibration data showed that for adults the optical and visual axis may differ by 4-5^{o} when the subject is looking straight ahead and by up to 6.5^{o} when the subject is fixating a point 30^{o} from the straight-ahead position. For newborn babies this error is even greater being in the order of up to 8.3^{o} for straight ahead fixations and up to 10^{o} for non-central fixations. This fits in with results from Mann's (1925) study of dead newborns' eyes which showed that because the medial part of the eye is less well developed than the lateral side at birth, the position of the macula relative to the optical axis is proportionately greater than for the adult, and only gradually assumes the adult proportions. Bower (1974), who also based his conclusions on drawings of dead babies' eyes, allows for an even greater degree of error claiming that a beam of light passing through the centre of the optical system of the infant eye will not strike the fovea but rather a point 10^{o} to 15^{o} on the nasal side of the fovea. Slater and Findlay argue that their results would explain reports of off-contour parallel scanning of a figure, and would throw open the issue of the neonate's ability to converge. Wickelgren (1967), using the normal estimates of areas being foveally fixated, claimed that the infant never showed convergence since the two eyes looked various distances apart. On the basis of this she suggested that results based on data from one eye would be unlikely to be a meaningful indication of newborn stimulus discrimination and preference since one eye might be fixating a given object although the other would not. Given Slater and Findlay's observations, this may not, in fact, be so. Since infants can make conjugate saccades this would enable them to maintain some degree of convergence.

Where the infant is most dramatically seen to lack the adult's scanning capacities is in his failure to re-orient to various parts of a visual field having directed an initial EM towards a given part of the field. Thus it is rather inaccurate to say, as do Ames and Silfen (1965), that the infant is usually held captive by the visual field or stimuli as such. Rather the infant seems to be open to only one part of the visual field as if the lack was in his information processing ability to deal with the degree of input which in turn led to a subsequent shielding of himself against "overpowering visual displays" by reduction in the power of peripheral stimulation. Alternatively the infant may be limited in the extent to which he can generate topics of interest to himself which would in turn specify which areas of the visual field were to be explored.

The warning note that was sounded by Slater and Findlay must also be borne in mind when evaluating conclusions based on data drawn from line of sight or corneal reflection recordings especially those from children under three years. Sorsby et al (1961) report rapid ocular development in the first three years, with the shape of the globe and the posterior segment, including the retina, changing so that the relative distance between the optical and visual axis is significantly reduced. Slighter and slower development continues up to the age of 14 years when adult proportions are approximated. Many studies have used these sorts of recording techniques and unless it has been explicitly stated that corrections have been applied to the data, as do Albutt et al (1974) with their on-line analysis of televised eye movements, only general conclusions can be validly drawn from the data.

Zaporozhets (1969) describes the infant's attention as appearing to be drawn involuntarily to certain salient properties of a visual display such as a large brightness contrast or a movement, rather than being characterized by active systematic searches. This picture of the infant's visual capacity even if accurate for very young infants, certainly does not fit the picture of the slightly older infant as revealed by studies of the development of the object concept and of object permanence. Bower (1974) reports some findings of R.Moore that stage II infants (2-4 months) searched for an object in the location where it had previously been presented even though it was placed in full view but in a different location. He also reports that with the transition test for object permanence, using opaque and transparent cups, stage IV infants (6-12 months) looked to the place where they have previously found the hidden object, ignoring the location where they have just seen it hidden and where in the case of the transparent cups it was quite visible. Consideration must also be given to Bower's (1971) finding that Stage II babies continue to track along the path of a moving object after the object has stopped moving. They will also look to the place where a stationary object has been seen resting before it moved, ignoring the seen movement. This behaviour does not seem to result from an inability to arrest on-going head and eye movements. Rather, Bower interprets the behaviour as a conceptual failure to identify a moving object with itself when stationary. It also means that the child's visual search is guided by conceptual considerations, whether or not they are appropriate to the real state of affairs, rather than being guided by the sensory information which is available to him. Bower seems to recognize this when he says, by way of explanation of the parallel between eye movement errors before 5 months and hand movement errors at a later stage, that "the conceptual knowledge that controls eye movements may have to be reformulated at a different level in order to control hand movements (pp.205-206)."

Fixation and eye movement measures have been used to indicate the ability of infants to discriminate between patterns or shapes or as measures of other abilities when questioning the subject is not possible. Salapatek (1973) has begun to examine the development of the ability to detect a discrepant figure in a field of otherwise homogeneous figures. Infants of 8 to 10 weeks did not selectively attend to a single discrepant element, although pilot tests with a 16 and a 24 month old child indicated that they were as able as adults to immediately attend to the discrepant element. Further preliminary studies found that the 2 month old infants tested were capable of detecting a multi-element discrepancy which suggested that infants would attend to overall density of contour transitions rather than to shape or one contour discrepancy. Zaporozhets (1970) reports a study by Veriger which found that 3 to 4 month old infants would orient towards the new element in a pair rather than to the previously presented remaining element. The most important message to emerge from these particular studies is that the ability to initially direct EMs to informative areas in very simple arrays is present at quite an early stage in development. However without other measures of discriminability one can only conclude that either the young infants did not detect the non-homogeneous element or else they were not motivated to attend to a figural discrepancy. After all, older infants are not motivated to attend to homogeneous figures yet it is not suggested that they cannot discriminate between the two kinds of figures.

Many of the findings reported here cannot be easily reconciled with the characterization of the infant as dominated by the stimulus array. On occasions the infant very clearly makes "projected" searches of the environment, while on yet other occasions there is an initial search which seems to depend on stimulus characteristics but subsequent eye movements are not attracted by other parts of the stimulus array.

1.4. Linguistic and Cognitive Development: Their Potential Influence on Scanning Strategies.

It seems a reasonable suggestion that after infancy one of the most potentially powerful factors to influence search strategies must be linguistically mediated cognitive developments. When Bruner (1968) articulated some of the important questions to be asked about cognitive growth processes during infancy he asked at least one question which remains relevant at several levels throughout childhood and also provided a direction in which to begin searching for answers: "through what means does the child gain control of his own attention? Put another way: How does the child learn to orient in a way that reflects the needs of search and problem-solving rather than the mere tracking of sensory change? Inevitably this must involve the infant's ability to represent his environment, to form a record of where things are and what uses they may serve.(p.6)"

The last sentence must be rephrased somewhat so as to allow not only for the need to study the child's growing ability to form representations of the world but also the need to investigate his growing ability to model where things are so as to anticipate as well as record.

With age language begins, however inadequately, to serve this function so that language may come to structure perception and action in addition to reporting it. Russian researchers in particular, following Vygotsky and Luria, have emphasized the importance of language for the development of voluntary behaviour, with the mediational aspect of language developing within the context of adult-child communication. Luria (1959) described how the functions language can come to increase with the development of the child, the nominative function serving to produce an orienting response in the child aged from 18 to 24 months while it is only after 2 years that language may serve a 'directive' or 'releasing' function seen when a child gives a general executive response to a linguistic stimulus, providing it does not conflict with previously established sensory-motor routines. The orienting and directive influence of a visual signal can be maintained over a short delay before some verbal signals lasting the same length of time have this directive power extended over time. It is not until 2½ to 3 years that sentences come to have a delayed directive function and serve to guide more precisely the activity of the child.

Language from an external source seems a more efficient regulator of behaviour at first and it is not until after 3 years that Luria reports the child as able to time his own positive verbal commands so as to direct his motor responses. Even so his speech has more of an 'impulsive' quality at this stage and it was only at 4 to $4\frac{1}{2}$ years that the child's own negative verbal response was found to have an inhibitory effect appropriate to the specific command. Luria argues that as soon as the semantic aspect of speech is able to control behaviour external speech becomes superfluous and internal speech takes over the directive function of language. If so, this takes a long time to become autonomous as it is not until $5\frac{1}{2}$ to 6 years that the pre-selective function of language allows the child to inhibit certain behaviours while facilitating others. Luria's well-known studies on the effect of language on voluntary behaviour only looked at manual behaviour which involved the pressing or not pressing of a bulb by a child in response to either the presence of a light or to an adult's or his own verbal instructions, or to both in conjunction. The effect of language on eye movements and scanning strategies which provide so much more precise and yet more comprehensive information about the world for the child has not been studied systematically.

The influence of language on perception is more amenable to manipulation and open to observation in terms of the effect of one person's language on another person's perception. It is from this viewpoint that the power of language will be considered in all of the following discussions, but it has not been overlooked that a person's own language must also come to autonomously structure much of his own thought and perception if he is to operate efficiently and adequately. It is not easy to show this for pre-school children but Blank and Bridger (1964) provide an example of how tasks involving temporal discriminations were impossible for children unless they were taught labels for the different sequences of lights. By age 4 to 4½ years language seems to have acquired a regulatory function in terms of gross motor actions, so that this age group would seem to provide a useful starting point from which to begin exploring the influence of language on visual scanning strategies. Certainly many researchers would agree with Slobin (1971) that by about 4 years of age children appear to have mastered many of the very complex structures of their native languages. Fraser, Bellugi and Brown (1963) found that by four years children had successfully passed all their tests of imitation, comprehension and production and Menyuk (1963) claims that all the basic structures used by adults to generate their sentences can be found in the grammar of nursery school children. However it is necessary to note that while children of this age attribute meaning to sentences and may act accordingly, the meaning attributed to certain kinds of sentences may differ quite significantly from an adult's interpretation of the same sentence in the same context.

So striking are the linguistic gains made between 1½ and 4 years that Palermo and Mofese (1972) have sought to redress the balance by stressing the additional development occurring between 5 years and adolescence. This point of view is in accord with theoretical stance of those who believe that language can only proceed within the framework of the child's cognitive level. Bloom (1970) Slobin (1973), Bruner (1973) and Gibson (in press) have all pointed to the infant's cognitive organization of experience as partially determining which meanings will be first expressed and which syntactic structures first differentiated. In a recent paper in which he considers the transition from pre-linguistic to linguistic communication, Bruner (1973) emphasizes the continuity of the uses to which communication is put, with later linguistic concepts like predication and case relationships being first realized in action and then in language. Gibson (in press) says "children necessarily begin to begin to talk about the things that they already know exist. They attend to the language which has to do with what they already know. As they become epistemologically more sophisticated, so does their language." This was a position taken up very early by Piaget (1969) p.3. who said that "children assimilate the language they hear to their own semantic structures, which are a function of their level of development." He has argued (1967) that although language frees the child's thought from the immediacy of the perceptual field and although it allows thought to be regulated by interpersonal exchange, language does not explain thought but is rather limited by the level of logical organization of the child. A series of studies reported by Sinclair-de-Zwart (1969) indicated that there was a difference in the use of comparative terms between conservers and non-conservers but that teaching non-conserving children to use these terms did not enable them to solve the conservation problems.

Other studies also show that even when certain lexical items are within the child's repertoire and superficially appear to be correctly understood in simple situations, they only come to be precisely and regularly used at a later stage of the child's development. One important aspect of linguistic development not completed by $4\frac{1}{2}$ years involves the use of comparative constructions. Findings from a longitudinal study reported by Donaldson and Balfour (1968), Donaldson and Wales (1970) and Wales and Campbell (1971), indicated that pre-school children were unable to perform appropriately when required to make comparative judgements using the marked member of the following pairs of terms: same/different, more/less, big/wee and other spatial adjective pairs, superlative as well as too- and enough- judgements. The terms to be investigated were categorized in terms of certain structural features as distinguished by the linguistic literature. Lyons (1968) designates one member of each such pair of terms as less restricted in its distribution than the other term. The less restricted term is referred to as 'unmarked' or as representing the positive pole of the dimension described by the terms, while the more restricted member is described as 'marked' or representing the negative pole of the described dimension.

Donaldson and Wales reported that while children ranging from 3;5 to 4;1 years were able to perform appropriately when judging the positive or unmarked term of a pair, their performance using the marked terms was very poor, and while it had improved significantly after six months there was still room for a great deal of improvement. The developmental sequence was such that the marked term was initially interpreted as if it was a synonym for an unmarked term, and with time it was sometimes assigned a correct interpretation and sometimes not and finally consistently assigned an appropriate interpretation. With superlative terms, during an early stage of development a marked term instruction often led to the choice of an object immediately adjacent to the marked term choice.

Cognitive development extending over quite a long period seems to be necessary before logical connectives can be used and comprehended appropriately. Neimark and Stolnick (1970a) and Neimark (1970b) found that even high-school children did not comprehend or use the term "or" appropriately with reference to the union of two classes of objects. Olds (1968) reports that only children older than 9 years appreciated the negative implications of the condition "unless". With respect to the development of temporal reference Cromer (1971) has argued that cognitive factors placed limitations on the grammatical forms and even the lexical elements which children could appropriately use for comprehending and providing descriptions of temporal events in a decentered way. The ability to decentre in temporal terms did not emerge until between 4;11 and 5;11 years mental age.

Other linguistic difficulties encountered by children are not due so much to a lack of specific cognitive abilities, but may be at least partially attributed to formal linguistic complexity. Anisfeld and Tucker (1967) found that although 5 year olds possessed the concept of plurality, often they did not know how to express it in a linguistically correct form, irregular forms being marked for plurality in an overregularized manner. Slobin (1973) cites the example of two

Serbo-Croatian/Hungarian bilingual children who were able to use various Hungarian case endings to appropriately express locative relations but who had at that time not yet developed equivalent locative expressions in Serbo-Croatian, which required the additional marking of direction notations. Also Slobin and Welsh (1973) report that children find it easier to use and understand the less complex full forms of linguistic constructions which adults tend to contract and delete. Olds (1968) found 7 to 11 year olds reponded more quickly to instructions where the relative pronoun was included rather than deleted.

Other kinds of linguistic complexity have been shown to affect children's linguistic comprehension. One source of difficulty, which is not overcome until about 8 years, arises when the minimal distance principle which applies to most verbs is broken either consistently as in sentences using the verb "ask" or without the subordinated interrogative pronoun being made explicit. Another source of difficulty arises when the surface structure subject does not correspond to the deep surface subject, not only with passive constructions but with sentences like "Is this boy easy/hard/impossible to see?" as contrasted with sentences like "Is the boy eager to see?"

The original studies by Carol Chomsky (1969) and Olds (1968) suggested that children progressed through a series of stages before errorless performance was achieved by 9 years. Further studies by Kessell (1970) and Cromer (1970) attempted to control more precisely the experimental procedures used and found the same sequence of development was passed through although at an earlier age. Cromer found that by a mental age of 6;8 years children were able to deal appropriately with most of the linguistically complex sentences, including passives, where the deep and surface structure subjects did not correspond.

Pro-nominalization also proved a problem for the children in Chomsky's study. It was only after six years that the non-identity restriction for pro-nominalized form was handled appropriately and only after seven years that the identity rule between a noun and subsequent matching pronoun was learned. Loban (1963) found pro-nominalization difficulties to continue until grade nine.

The discussion has thus far pointed up the fact that while the young child from 4 years onwards has at his command many grammatical structures and words, he may be using them in certain limited ways due to an inability to deal with the degree of cognitive or linguistic complexity or both that is involved. This point, which has been argued with more skill and cogency by Cromer (1974), has been drawn out somewhat laboriously because of its implications for studying the influence of language on scanning strategies. If language can be seen to influence visual search, then measures of various aspects of these searches may reflect the developing ability of the child to deal with more complex linguistic and cognitive structures. These measures may provide a valuable additional means of assessing the way in which the child's ability to use language already within his repertoire as well as new forms comes to approximate the adult usage. The measures could be used to corroborate findings about many of difficulties already discussed such as pro-nominalization and other kinds of ambiguity.

Before adopting the proposal to use eye movement measures as a means of revealing something of the cognitive processes lying behind the child's decisions to act upon and respond to the world, a careful consideration must be made of the possible relationships between the measures and the cognitive processes. Thus a concept might be understood in a more or less adult way but not used to direct eye movements efficiently. Alternatively the concept may not be understood in an adult fashion but the scanning strategy may be appropriate for the particular task for other reasons. Even if one takes into account the criteria being used for a judgement by a child at his own stage of development, he may or may not adopt appropriate minimal scanning strategies in accord with these criteria. These are some of the knots that will need to be disentangled before any definite relationship can be postulated between scanning strategies and linguistic and cognitive development.

Those aspects of linguistic and cognitive development which were in fact selected as being particularly amenable and in need of investigation within the context of this thesis, with its general concern to study the development of scanning strategies, were as follows: the spatial preposition pairs "at the top of/at the bottom of" and "in front of/behind"; active/passive sentence constructions; and positive and negative quantifiers, namely "all", "every" and "no" and "none".

Discussion of the literature connected with each of these aspects of language development has been deferred until the individual chapters which consider whether and how a child's scanning strategies in various sentence verification tasks are influenced by the content and structure of the sentence.

The rest of this chapter follows up the questions so far raised about the development and use of scanning strategies by reviewing those studies which have measured the performance of adults and children during various tasks in terms of eye movement parameters. These questions ask whether language is one of the factors influencing search strategies, and if so, to what extent and under what conditions does it operate. They also ask whether the level of linguistic development, largely underpinned as it is by cognitive development, is reflected in the measures of scanning strategies. Adult studies are considered first so as to provide some idea of the level of mature functioning.

1.5. Adult Scanning Strategies. The literature will be reviewed for information about which factors are most influential in determining the adult's scanning strategies in a variety of situations.

Early studies were concerned to examine the influence of the visual stimulus itself as well as the effect of explicit and implicit instructions as to what to look for in pictorial arrays. Buswell (1935) observed subjects' eye movements by means of a corneal reflection technique while they looked at photographs of pictures, drawings, sculptures and patterns. He was mainly motivated by a desire to see how people responded to artistic works and whether their visual search bore any relationship to the structure of the picture or to the viewer's aesthetic judgements and responses. However he also varied the structure of the task by asking subjects to re-examine some pictures looking for a given characteristic or else to look again having been given a passage of comment on the picture. By comparing the number, loci and duration of the fixations made, Buswell provided an indication of how specific task constraints and changes in knowledge of the array might change search patterns.

The results indicated that individual differences in viewing patterns accounted for more of the observed behaviour when merely inspecting a picture than did the arrangement of the picture or its design. However one common feature of the viewing patterns of both adults and 11 year old children was the tendency to generally survey the whole array with a series of quick saccadic eye movements and to then concentrate on smaller areas with longer fixations. Buswell saw this increase in fixation length with time as related to processes of reflection and interest which required additional time for consideration and not as being due to difficulty in processes of recognition.

Yarbus (1967) was particularly concerned with cognitive factors influencing eye movement patterns. Even when he discusses the sorts of stimulus characteristics that attract the subjects' gaze he assumes that the elements attracting attention must contain potentially useful information for the observer. This approach seems to have been forced upon him since he was unable to find any common stimulus characteristics such as colour, brightness, familiarity or size of objects, which would account for why some areas on each picture attracted the observers' gaze while others did not. In fact Yarbus found it necessary to consider the distribution of points of fixation on each picture in a post-hoc fashion by taking into account the meaning of the content of each picture. Even the meaning of the picture seemed to vary depending on the task in which the observer was engaged. When subjects were asked different questions about a picture they gave different scan patterns which often included areas overlooked during a free examination of the picture. Analysing eye movements made during reading Yarbus makes the same point as Buswell, namely that prolonged fixations seem to correspond to the processing of some particularly difficult aspect of the fixated material. He also commented that over an extended period of viewing running into tens of seconds viewers tended to repeat their initial sequences of fixations.

Noton and Stark (1971), using photocell recordings of subjects' eye movements while viewing line drawings in a dim light, also found individual cyclic regularities in a subject's fixation points which occupied from 25% to 35% of viewing time. They took the cyclic scan patterns to represent the serial extraction of features from the stimulus during an initial 'learning' phase, which could then be repeated when trying to recognize the original picture from among others. They suggested that each visual stimulus could be matched against the individual's internal representation in the form of an ordered list of features, the matching process being self-terminating if a mismatch was found. This view is partially supported by studies like those of Donden and Case (1970) and Gould and Peeples (1970) which found that it can take longer to recognize a target object than a non-target, especially when complex targets were used. However Donden and Case pointed out that same/different judgements of simple geometric shapes can be made with information from several sources being processed in parallel.

Noton and Stark's study also raises the problem that has bedevilled many eye movement studies - that of specifying the features of 'informative' or 'important' areas of a visual display independently of the eye movement data. Mackworth and Morandi (1967) proposed one solution which involved comparing the areas of pictures receiving the highest number of fixations with independent assessments of the recognizability of these areas. They found subjects were most likely to explore areas containing unusual details and unpredictable contours rather than those with predictable or redundant contours. It was pointed out that the processing and rejection or selection of potentially informative areas must have been mediated by peripheral vision since much of the pictures was never directly fixated at all. This suggests that peripheral vision may be able to confirm predictable outlines and regular textures leaving foveal vision to explore the more unpredictable areas of the visual field, with "unpredictability" being defined relative to the task at hand.

Mackworth and Morandi argue that while the nature of a stimulus may in certain cases be most important for determining which parts are selected for detailed attention this very much depends on the stimulus and the task. Thus data from line stimuli emphasizes the role of straight lines, redundant contours and changes in direction of boundaries. But these conclusions do not necessarily apply to textured or more complex pictorial representations, especially when inspected for purposes other than recognition, matching, etc. It seems worthwhile to ask how information content could be specified by taking account of both the stimulus characteristics and the task prescribed either for or by the subject.

Howe (1970) tried to do just this by comparing the length of saccades and durations of eye movements made when subjects were in a free exploration situation or carrying out a recognition task, with meaningful and non-meaningful visual arrays being used for both tasks. These arrays consisted of scenic displays, computer generated random dot patterns or random line shapes. Eye movements were measured by electro-oculography. There was little difference between the mean fixation times, the average fixation time allowing for three fixations a second. The only significant difference was between the mean length of the saccades made during recognition, with longer saccades being made for the random shapes than for the scenic photos. Howe interpreted this finding as showing subjects more willing to make non-overlapping fixations when the stimulus material was homogeneous. Regardless of the spread of eye fixations there was no indication that the "eye" followed the contours or the edges of objects.

Gould and Peeples (1970) also failed to find any differences in eye movement measures which depended on the sort of patterns used in a pattern matching task. The task for the five subjects involved a search of a display of eight patterns arranged in a square around a standard in order to determine how many of the patterns matched the standard. Three classes of straight-line patterns were used: meaningless, symbolic and object pictures. Eye movements were measured by a corneal reflectance eye-marker system. The class to which a pattern belonged did not affect total scan time, errors, fixation duration or number of eye movements. Gould and Peeples concluded that in visual search tasks, pattern discrimination relied more on the physical structure than the meaningful content of the patterns. This is not really surprising since in this task the individual patterns could each fall within the foveal region when fixated, making holistic recognition a possibility and the usefulness of a verbal distinction between meaningful and meaningless stimuli unnecessary. Certainly recognition was not a problem since subjects did not need to refixate meaningless patterns more often than the meaningful ones. The role of the meaningfulness of the visual material viewed still requires assessment in situations where the "meaningfulness" itself is meaningful within the context of the task!

Certain interesting findings did nonetheless emerge from the study. Subjects tended to scan all the patterns each with his own individual way of ordering his search, none of them relying on peripheral information to make a discrimination as Gould and Peeples had suggested. The results also confirmed Gould's (1967) previous findings that the length of fixations on a pattern increased with its increasing similarity to the standard pattern against which it was to be compared.

Moreover the central standard patterns were fixated longer than target patterns even when they were identical, suggesting that a completely accurate representation of the standard requires longer to be set up initially than do subsequent comparisons. This is similar to Norton and Stark's suggestion that memory traces of a 'feature ring' are laid down during initial familiarization fixations.

In pursuing the matter of the effect of cognitive constraints still further, the findings of Loftus (1972) will now be discussed. He looked at movement and fixation measures taken while the subject was carrying out a picture recognition test in which a long series of pictures were presented two at a time, with a later test for recognition from a larger set of pictures. Giving each picture of a pair a pay-off value seemed to affect recognition scores through the mediation of the number of eye movements made. Higher valued pictures were given more fixations during a limited presentation time and were better remembered but memory performance was independent of pay-off value and exposure time when the number of fixations was held constant. A distracting task was found to have a detrimental effect on recognition performance over and above reducing the number of fixations made. Memory for non-fixated pictures was not above chance. Loftus explained the findings by assuming that regardless of the many decisions made during a fixation, like the laying down of visual or verbal encodings and the direction of the next saccade, each fixation could be regarded as yielding a single measure of memory strength so that the more fixations made the greater the memory strength.

However Tversky (1974) found negative correlations between the number of fixations on a picture and the recall or recognition of the picture. She suggested that when fine discrimination was required subjects were able to compensate for fewer fixations by gaining more information per fixation. The finding emerged from a study designed to discover if expectations about the requirements of the task affected the location and number of the subject's fixations or if it rather affected how much information the subject took in with each fixation. Subjects did indeed perform better on the test for which they had been prepared, but this did not seem to be mediated by selective viewing of either the picture or its written label. Subjects fixated the picture part of the stimulus nearly twice as often as the label under both task conditions, possibly because the label could be quickly read or inferred from the picture or was less informative. She points out that control of fixation by encoding strategies has been most clearly demonstrated in situations where the same or very simple and similarly structured arrays have been repeatedly presented with fairly long exposure times.

Control of fixations by direct linguistic means has been revealed by Cooper (1974) who found that adults are able to spontaneously direct their line of sight to those elements of a pictorial array which are most closely related to the meaning of the linguistic information being heard. Subjects were required to look at four arrays each consisting of nine discrete pictures of well-known objects arranged in a three by three matrix. At the same time they listened to a prose passage containing words which were presumed to have strong, weak or no necessary associations with the pictures. For three arrays subjects simply listened to the stories. After the last of these they were given a surprise comprehension test and before the fourth array they were warned of a comprehension test to follow. Control subjects underwent the same procedure except that they viewed arrays after they heard prose passages that did not correspond to the arrays at all. Eye movements were monitored and recorded using a corneal reflection technique. The results showed that the experimental subjects directed their eye movements to the appropriate pictures four times more often than the control subjects viewed these pictures. The extent to which the fixations were directed to certain pictures depended on the strength of the association.

The most impressive aspect of the results was the speed with which subjects were able to interpret continuous speech and use it anticipatively in the context of the visual field. Nearly 55% of all fixations that were directed appropriately to an associated picture commenced before the completion of the relevant word, while another 40% of the fixations were initiated within 0.2 seconds of the end of the word or else before the beginning of the next word. The findings seem to establish the feasibility of getting a sensitive measure of "active, on-time, anticipative" processes resulting from linguistic constraints without interrupting the flow of language or making the subject aware of his responses. The processes measured could in turn reflect how people interpret spoken language. The next experimental step requires that the visual field accompanying the language should more realistically represent the meaning of the spoken language.

Another study which was explicitly concerned with the effect of the meaning of language on scanning strategies was reported by Carpenter and Just (1972). On each trial their subjects were required to judge a previously presented sentence describing the relative quantities of two sets of coloured dots, against an array containing the two sets of dots. Eye movements were recorded using a wide angle camera with a frame of lights providing the reflectance markers. Ways of quantifying objects were expressed in various linguistic forms, so that situations where the smaller subset was red were correctly and variously described as "a minority/small proportion of the dots is red" and descriptions of the larger subset were expressed either positively as in "many/most/lots of the dots are green" or negatively as in "few/hardly/scarcely any of the dots are red". The overall results showed that the subjects predominantly fixated the subset which was quantified in the semantic presupposition underlying the sentence and not the subset superficially referred to in the sentence. However this pattern did not hold for both true and false judgements. Nor could Carpenter and Just convincingly explain the interaction of truth value and form of quantifier within the scope of their sentence/picture verification model.

Gardner and Long (1961a, 1961b) have postulated that individual consistencies in cognitive control principles are important for understanding scanning behaviour in various size estimation tests. They claimed that two principles seemed to independently effect the accuracy of size judgement; firstly the 'extensiveness of scanning' measured in terms of the number of eye movements made on the object to be judged; and secondly 'field articulation' or 'centration effects' which were taken as the duration of each fixation and seen as taking the form of selective attention to relevant rather than irrelevant stimuli. Attempts were made to relate these principles to performance on various other tests such as the Roscharch and colour-word test. Gardner and Long finally conceded that these individual consistences only influenced performance on the size estimation tests under certain conditions. Greater extensiveness of scanning lead to more accurate size judgements when the size of a simple configuration like a circular disk was to be estimated. Field articulation was more important when the judged figure was embedded within a compelling irrelevant context as in Delbeouf's concentric circles illusion.

What is more interesting to ask is how people's characteristic modes of scanning are modified or reinforced by the requirements of the situation as determined by the interaction of the task and the stimulus material.

<u>Summary</u> For adults it seems that the factors influencing scanning strategies vary according to the demands of the task, so that in the final analysis cognitive factors are most important. Adults scanning strategies can be shown to be influenced in situations where the subject is required to look from object to object as well as scanning within an object. The adult seems to operate on such principles as

producing the greatest similarity between internal models and external reality and gathering information that will allow for most efficient prediction for the future. 'Attracted' and 'projected' scans are made as is appropriate for a particular situation.

1.6. Visual Scanning Strategies during Childhood. The studies selected in this section as providing relevant information about scanning strategies during childhood, vary considerably in the degree of linguistic structuring of the situations during which the eye movement measures were recorded. Some deal with the child's performance in fairly unstructured situations as far as the instructions were concerned: either one instruction was given to cover a number of trials or else the child was simply told to look or to look and remember a designated visual array. Other studies evaluate the child in more structured situations which would better allow him to reveal whatever capacity he had for planned visual activity.

Zaporozhets (1970) provides a summary of some of the valuable contributions made by Russian researchers, who have been concerned with the development of perception in the pre-school child. Those whose work is reported have followed the line that the function of orienting and exploratory movements, be they visual or manual, is to investigate the object and form a copy or mental likeness of it. Zinchenko for instance, has drawn a parallel between the development of manual and eye movements from children's behaviour in situations where the child was required to learn to recognize a new object with an irregular form.

When the child was allowed manual but not visual access to the object, the three-year olds tended to grasp and manipulate the object rather than to examine it. By 4 years they were beginning to use the palm and the fingers, usually of one hand only, to touch or palp parts of the figure. The two hands and fingertips were being used by 5 to 6 years but exploration was concentrated to one part of the figure without being related to the other parts. Only after 6 to 8.5 years did the children show any systematic tracing of the outline of the figure with their finger tips. and ability to successfully visually recognise all the figures manually explored.

When only visual access of 20 seconds per figure was allowed, three and four year olds made relatively few and longer fixations which were nearly always made within the boundaries of the figure. Children from 4 to 5 years made more and shorter eye movements which were more evenly spread over the area covered by the figure. Although the 5 to 6 year olds traced only part of the outline of the figure this enabled them to perform well in recognizing the objects. Children from 6 to 7.5 years correctly recognized all the figures. They characteristically followed the outline of the figures and made wide sweeping eye movements linking various areas of the figures, although with longer training in the recognition and discrimination of figures the number of eye movements was abbreviated so as to concentrate on the most informative features of the object.

From this research the picture emerges of the young child up to 5 to 6 years being unable to carry out an efficient visual examination of an object for the purposes of a recognition task. But this picture should only be regarded as a preliminary first sketch rather than the final portrait, framed and hung. There is no evidence to refute the possibility that the poor recognition was due, not to initial inappropriate scanning strategies, but rather to poor memory at the time of recognition testing, when this was carried out subsequently. Nor can any conclusions be drawn about the child's behaviour in a situation which allowed him to plan 'projected scans' or gave him information in terms of which he might 'pre-set' an attracted scan.

A study by Mackworth and Otto (1970) suggests that the ability to use peripheral information to direct eye movements to a clearly defined informative area in a visual display develops very early in normal children. Using a corneal reflection technique to record eye movements they found that their subjects, who ranged in age from 2 to 7 years, spent two-thirds of the presentation time of a matrix of 16 identical shapes looking at one shape that turned red soon after the presentation of the matrix. Habituation to the discrepant element was not complete after 20 trials, and age had no effect on orienting and habituation. When the same task was given to ten normal and ten aphasic children between 5 and 10 years, the normal children were able to rapidly orient and then habituate to the novel element, whereas the aphasic children with severe impairment of verbal comprehension showed prolonged orientation without habitation, while those with mild impairment failed to orient to the novel element and occasionally failed to attend to the display as a whole. Failure to make appropriate orienting responses was taken as a failure to use peripheral information to locate the informative areas in pictures and failure to habituate was seen as a failure of the subject to form a neural model of the external stimuli. Although the nature of the relationship between language and perceptual difficulties cannot be articulated more clearly, other than to say that they seem to be associated, the problem is obviously worthy of more attention.

Wolf (1971) provided a scanty report of an elaborate study by Wolf and Guba dealing with children's scanning patterns while watching 19 minutes of various kinds of television films. Their eye movements were recorded by means of a corneal reflection system based on the Mackworth (1967) camera. The intention of the study was to relate the number and locations of fixations made to particular characteristics of the stimulus materials and of the subjects.

The stimulus materials differed in terms of such variables as subject matter, the visible presence of a narrator, the pace of changes of visual frames, the number of new elements in each successive frame and the presence of superimposed words. Subject differences were arranged in terms of age, with children from grades 6, 8 and 11 being used, and in terms of intelligence. Mention was also made that recall of stimulus information was used as another measure of subject differences but no results were given relating to this measure, nor was any indication given as to whether subjects were aware of this task requirement before viewing.

A variety of results emerged from the study, providing some leads to the sorts of factors affecting children's scanning strategies. Cluster analysis of the eye fixations indicated that the addition of a novel object to each successive frame of the film only attracted the subject's attention up to a certain point of overall complexity. The presence of a narrator sometimes detracted from the number of appropriately directed fixations, while the presence of superimposed words did not attract many fixations. This may have been because they were redundant or quickly read. A tendency was found for high IQ subjects to be more mobile than low IQ subjects in their viewing patterns, with the attention of the high IQ subjects being more quickly directed to newly presented objects and new areas being explored in repeated presentations. Wolf suggests that this may be attributed to faster processing of stimulus material by high IQ subjects. However these findings must be treated with caution as they may only reflect differences in the way pictures are viewed when no specific instructions have been given explaining the purpose of viewing the films.

While an impressive amount of data was available from this research, the generality of the conclusions that can be drawn are very much limited by the lack of specification of the complex variations in the linguistic comment on the visual stimuli and on the visual materials themselves.

Given the present amount of knowledge about the variables that influence the way people visually explore their world, it would seem that experiments, which are more limited in scope but using more precisely defined variables, may be more valuable.

One such study. by Levy-Shoen and Pouthas (1972), which is discussed more fully in Chapter 2, required both adults and young children of 3 to 5 years to identify two pictures presented simultaneously but at different locations. In such situations certain spatial locations of the pictures were found to influence the order of fixations allowing for exploration of the visual field. However no attempt was made to determine whether and at what age specific verbal instructions might overcome or interact with the influence of spatial factors. It was with this question in mind that the first set of eye movement studies reported in Chapter 3 was designed and carried out. Another question raised by the study concerns the danger of assuming, as do Elkind and Weiss (1967), that the ability to systematically explore a pictorial array corresponds to the order of naming the items making up the array. Some of Levy-Scheon and Pouthas' findings indicate the possibility of scanning an array in a given order and reporting it in another. This possibility cannot be further examined until evidence is available about a voice-picture lag similar to the voice-word lag found in reading (Leven and Kaplan, 1970).

Another study providing valuable evidence about the child's visual performance within the context of an identification task, is one by Mackworth and Bruner (1970). Using the Mackworth corneal reflection technique they investigated the ability of 6 year olds and young adults to identify photographs which required either 'visual comprehension' if the picture was blurred or else 'casual inspection' if the picture was clearly focussed. Using a variety of scanning indices they found many differences between the visual behaviour of adults and children and were able to point to some of the consistencies that seemed to underlie these differences.

The main finding to emerge was that children, while able on occasions to make detailed searches of informative areas once located, and able on other occasions to cover the visual field for relevant areas, often fail to co-ordinate both sorts of search in a common master scanning programme. When visual comprehension was required the children did not concentrate their gaze on the same areas chosen as informative by adults, nor was there agreement between children on those areas on which they did concentrate. Moreover the children made many more long 'leaping' eye movements than adults during the initial period of viewing the very blurred photos. Since these eye movements were not between informative areas, Mackworth and Bruner described as inappropriate this scanning before the establishment of any informative areas to inter-relate.

Difference between adults and children were not so apparent when focussed pictures were being examined. In this situation children sought out much the same areas as adults for detailed search but they did so at the expense of broad scanning. Unlike adults, they seemed unable to monitor peripheral vision for areas of potential interest while processing information from the areas under direct scrutiny at the same time. It was adults who made the large saccades enabling them to link and synthesize the information from various parts of the pictures, while the children's track lengths were much shorter than adults since most of their fixations overlapped around the few informative areas fixated. On the whole however the child's performance seemed much closer to the adult's in terms of fixation times when a focussed picture was viewed than results from reading situations would suggest. The effect of making it more difficult to match internal models against external patterns was similar for adults and children in terms of increased fixation times. While this study has provided fascinating information about methods of analysis of eye movement data as well as pointing up the differences between adults and children in simply identifying a picture, the authors themselves regard it more as a study of the relation between perception and the properties of the stimulus picture, rather than the influence of the viewer's interpretation of the task and his cognitive experience and organization. Mackworth and Bruner point the way for further research when they say: "Further studies of this interrelationship between peripheral and central seeing would be most valuable if children were compared with adults in various kinds of task which allowed analysis by eye movement studies of the schemata, strategies, programs and plans that the S was trying to utilize to achieve success." (p.165).

There are several studies which have attempted to do this. Nodine and Steuerle (1971) found there was a developmental trend between 6 and 9 years in the ability to make efficient same-different judgements between briefly exposed pairs of letters. Older children required fewer and shorter fixations, proportionately more of which were on distinctive features and more cross comparisons than did the younger children. Vurpillot (1968) recorded the scanning strategies of 78 children between 2;11 and 9;6 years while they searched a picture of two houses in order to decide if they were 'the same' or 'different' with respect to six windows of which either 1, 3 or 5 could differ. The eye movement records made by a corneal reflection technique, allowed for a comparison of the strategies employed by children of different ages and by children giving correct and incorrect decisions. Vurpillot found that children younger than six never took into account all the information that was needed for an appropriate judgement and that a completely systematic scanning strategy of paired comparisons is only very gradually achieved. A comparison of the scanning strategies of those giving correct and incorrect decisions was used to assess the criteria on which subjects based their decisions. On this basis the children were divided into three groups. Those whose judgements were not related to the information they had gained from the visual inspection which was carried out in an aimless fashion, were assigned to Group C. Those children for whom one common element between the two houses signalled an identity and one difference signalled a dissimilarity, regardless of position, were designated as Group B. Only for Group A subjects was identity defined as the absence of any difference found after paired comparisons. Most of the children from 6;6 to 8;9 years fell into Group A, while children between 5;0 and 6;6 years were equally divided between Groups A and B and children under 5;0 years mostly fell into group C and the rest into Group B.

Thus it is by definition that changes in scanning strategies accompany the changes in the child's cognitive organization that underlie his understanding of the terms 'same' and 'different'. Nonetheless it would seem that changes in cognitive organization influence the way the child goes about searching the visual field, since the chances are extremely small that every child would come to make paired comparisons by chance and that this would result in changes in the judgements made due to the different information being gathered. There is however a more overriding constraint on his scanning strategies which the child needs to acquire. The child needs to situate his search for information within a frame of reference which allows him to remember and check where he started his search and what information he has acquired against what information is available and what is required. Even Group A children who used adult criteria for judging that information which had been collected through paired comparisons did not always complete all the necessary paired comparisons.

Olson (1970) sought to both qualify and extend Vurpillot's findings. He suggested that the incomplete nature of children's search of the houses may have been due to their limited expectancies about how the alternatives might differ. He attempted to examine the effect of expectancies by varying the task the subject was to use the information gathered from his visual search to carry out. He also wished to see if visual search differed for stimuli possessing a specific feature list like a house as opposed to figural patterns like an X or a diagonal which do not apparently possess such discrete attributes. Olson was looking to inadequate visual searches to explain young children's unsuccessful attempts to reconstruct diagonals but it should be noted that an inadequate conceptualization of a diagonal may have led to both the poor visual search and the poor reconstruction of diagonals.

Fifty-seven children between the ages of 4;4 and 7;3 years viewed a diagonal pattern, having been previously told whether they would be required to reconstruct it or recognize it from among two others. Only 13 of these children then performed the recognition task with five house stimuli, one of which provided the model against which the four others were to be compared. Four younger children from this group were recalled again so as to examine the effect of pointing out overlooked features of the houses on their viewing and subsequent task performance. Eye movements were recorded using the corneal reflection of the stimulus to determine which areas were being fixated during presentations of the stimuli. Younger children from 4 to 5 years made more fixations of the pattern than older children from 6 to 7 years whether they were required to recognize or reconstruct the diagonal. The older children made 85% correct recognition judgements while only 33% of younger children's judgements were correct. The two groups did not differ in the extent to which they fixated the critical information, nor was there any difference within groups for those giving correct or incorrect judgements. Both groups were able to construct the test diagonal correctly. Those making recognition errors were able to correct their judgements when given a second opportunity to view the test stimulus after having viewed the alternatives.

With the diagonal test situation, the recognition test required the child to select a picture that was the 'same' but with the house test situation the child was required to make 'different' judgements since each of the comparison houses differed from the test house with respect to one feature. The younger children were very bad at giving different judgements making appropriate judgements on only 19% of occasions as compared to the 65% of responses made correctly by older children. These percentages rose to 33% and 85% respectively when a second comparison was allowed. Olson links the children's poor performance to their incomplete examination of the critical features of the test stimulus since the older children viewed an average of 3.6 of the four critical features and the younger children fixated on average of 2.6 features.

Olson provides no information about whether the length of the stimulus presentation time was fixed or unrestricted. If it was limited to a given time period then the younger children probably viewed fewer features because their average fixation time was much longer than that of the older subjects. This would mean that the inadequate searches of younger children would result from constraints on their rate of processing rather than a failure to appreciate which features should be examined. In any case, even an adequate initial survey of the test house did not ensure that each of the features would be checked on each of the comparison houses subsequently presented. Memory factors have to be considered at this stage, since when the critical features were pointed out by the experimenter the children were able to use this information to structure their subsequent search. One further finding indicated that the degree of search did not correlate with an appropriate judgement since a missing feature might be detected first or might take longer because other features were checked first.

Definite conclusions cannot be drawn from this study regarding the basis of the inadequate scanning strategies and inappropriate judgements. However it would appear that by providing the child with a framework to guide both his 'attracted' and 'projected' scanning, usually by linguistic means, the child's search became more precise and consistent. Olson says that the older children appeared to differ from younger children - "not so much in their ability to carry out a visual search, but rather in terms of their initial assumptions of what to look for." This proposition needs to be put to a more rigorous test which would take into account the various factors such as memory limitations and the determination of judgement criteria, which may account for differences in a child's ability to make appropriate visual searches.

Nonetheless results from a study by O'Bryan and Boersma (1971) may be interpreted as supporting Olson's general contention, even though they used eye movement data as measures of performance in quite a different task. Using the corneal reflection technique they looked at the eye movement patterns (EMPs) of children at various stages in the development of the conservation of length area and continuous quantity while they actually performed conversation tasks. The study was based on Piaget's view that increasing decentration through developing perceptual activity finally allows the child to free himself from the perceptual dominance of any particular parts of the field. From this viewpoint the conserver is seen as displaying no tendency to centre on any one part of the stimulus field.

Indeed O'Bryan and Boersma found that various analyses of eye movement measures did reveal appropriate differences between conservers and both 'strong' and 'transitional' non-conservers. Over the total time taken to solve the task, strong non-conservers fixated the greater element of the two being compared significantly more often than the less element on all the conservation tasks, while transitional conservers did so on only half the tasks and conservers showed no such differences. The conservers made more eye movements or couplings between the relevant elements and a greater total number of fixations than non-conservers whereas both the non-conserving groups tended to make more runs of fixations on the same element than conservers. Thus the conservers showed more perceptual activity than non-conservers which took the form of shifting the gaze between the elements to be compared.

On the basis of this very clear finding the authors concluded that in a conservation-testing situation non-conservers are distracted by the clearly visible changes taking place in the visual field, but lack a means of overcoming the effect of irrelevant perceptual cues. Now while the findings may not be disputed, it does not necessarily follow that it is an increase in perceptual activity which enables children to make conserving judgements. Rather, it may be that as the child becomes aware that the task involves checking that nothing is added or subtracted from either element, this leads to the increased perceptual activity. Although no way of resolving this problem is apparent it should be borne in mind that perceptual activity may be changed by cognitive restructurings as well as the reverse situation obtaining. Moreover it should be noted that decentration per se, in the sense of not centering on any particular part of the field, is not necessarily the most appropriate perceptual activity for all situations. The most general characterization of perceptual activity appropriate for a wide variety of situations must be framed in terms of what is involved in carrying out an efficient search whether it involves centration or decentration.

A series of experiments by Faw and Nunnally (1967, 1968a, 1973) can be seen as investigating the development of both 'seeking' and 'attracted' scans. They have been concerned with the effect of the affective tone, the complexity and novelty of stimulus materials as well as the effect of different kinds of experimental instructions on the preferences shown by adults and children. Complexity was defined as the number of sides of geometric figures, while novelty was defined as the incongruity of the elements comprising certain configurations.

The 1968 study showed that when pairs of pictures were shown to male children from 7 to 13 years of age, the fixations of the children were overwhelmingly made on the more complex, more incongruent stimuli and also on stimuli rated as having negative affective value. This last finding also held up in a later study (1973) which used female children aged from 8;11 to 11;8 which attempted to make the testing situation more natural and to rule out confounding factors of novelty or complexity which may previously have been confounded with affective tone.

The effect of stimulus properties was also investigated for male adults who were also given different kinds of experimental instructions before being presented with the pair of pictures. One group was told to look at whichever picture they preferred, another that it didn't matter where they looked, while a third group received no instructions. Up to a certain low level of complexity more complex pictures received more fixations. Novelty was an important factor directing attention for the two groups given no specific instructions, but an instruction to look at the preferred picture cancelled out this effect. Affective tone influenced visual exploration by increasing the number of fixations on pictures rated as having a positive affective value, with an instruction to look at the preferred picture increasing this tendency.

The lesson to be drawn from these studies is that scanning patterns between pictures unrelated with some larger thematic framework may differ quite significantly depending on the more 'psychological' stimulus characteristics such as novelty and affective tone and on the instructions which have implications for other situations. . If people's ability to search the world actively is to be assessed on the basis of linguistically unstructured situations then their capacity to extract information from the world may be greatly underestimated. Language may be the great leveller where looking informatively is concerned.

Piaget and Inhelder (1966) summarize their view of the child's perceptual development from 4 to 15 years in terms of the increase in the number and quality of the child's perceptual activities. Distortions and illusions are seen to result from 'field' or 'centration' effects, which arise during a single fixation and can only be compensated for, as the child learns to make systematic searches so that the significant parts of the field of view are explored thoroughly.

Piaget and Vinh-Bang (1961) studied the eye-movements made by adults and children as young as 6 years while they compared the lengths of lines arranged in various ways with respect to each other. They reported two main differences between the visual behaviour of younger and older subjects: "First in the child the points of fixation are much less accurate and are distributed over a much larger area than in the adult (up to several centimetres from the line in question). Second, the movements of transfer and of comparison made in scanning back and forth from one segment to another are proportionally less frequent in children than simple displacements of a random nature.(p.40)" Since children do seem to make searches which cover large areas of the visual field any explanation of centration effects must rest more heavily on the child's failure to make a systematic search rather than on a failure to make any compensating eye movements at all.

Piaget argues that these findings fit in the description of the perception of young children under about 7 years as syncretic or global, since the subject gains only a total impression of a complex configuration without analysis of the parts or synthesis of the relationships obtaining between the parts. He cites the example of young children describing an ambiguous figure, not in terms of the alternate interpretations such as "scissors" or "a man", but rather as "it's a man and somebody threw a pair of scissors in his face". However if the child has gathered enough information to identify the alternate interpretations it seems unlikely that he has made an inadequate visual search. A more probable explanation is that it is the description that is global or else that eidetic memory of the two interpretations allow the child to combine the two perceptual experiences into one. The label of syncretism may perhaps be more approp-ropriately restricted to some of the behaviour of far younger children. Stern (1924) describes how his daughter of 4;4 years failed to recognise as a bottle a simple line drawing she had as an infant called a bottle. It would seem that by 4 years this child was no longer satisfied with the general impressing of a drawing and had more complex criteria against which she hade her visual judgements.

Piaget also proposes that it is only after seven years when the first logico-mathematical operations are co-ordinated that perceptual activities can be directed by an intelligence that has a better grasp of a problem and is able to order the way visual information is collected. The older child of 9 or 10 years will be able to make use of references and directions that would be overlooked at 5 or 6 years. This evaluation of the child's capacity to use his visual sense intelligently has been based on children's performance in a task where they may have had little interest in perceiving accurately, and it is not necessary generalizable to other situations. Two questions still need to be distinguished and remain to be answered.

One question asks whether children can direct their eye movements appropriately when they do operate with an adult's set of criteria for various concepts as assessed by other measures. The other question asks whether the child is able to use his particular way of characterizing the world to perceive the world, even when his conceptualization does not correspond to that of the adult.

Although the studies reviewed have indicated that many factors may influence the way the child goes about organizing his visual world, no comprehensive picture is available as to his capacity to order his search according to the demands of a task which is explicitly stated and involves dealing with undegraded, meaningful visual stimuli. Several studies have supported the idea that at some points throughout infancy, early and late childhood the child uses whatever intellectual skills he has to organize his search. Far from the gaze only being controlled by the properties of the stimulus and its intrinsic features, there are many occasions on which the child shows such limited or random coverage of displays that it is hard to see how the gaze could be characterized as simply susceptible to attraction from any part of the stimulus field. Other factors such as the child's habitual occular-motor patterns, the meaning he can attribute to the array and the problem facing the subject must affect the way he scans an array. There are other occasions on which his eye movement patterns do not obviously correspond to either the visual array or the problem facing him.

Mackworth and Bruner are also aware of the possibility of discrepancy betwen early capacity and later behaviour. They have noted that it takes a long time before the early ability to respond anticipatively to an object and the loci where it can appear (Mundy-Castle and Anglin,1969) comes to be applied to more complex, noisy or ambiguous displays. In the same way both 'attracted' and 'projected' scanning strategies can be made by the child very early on in development but it probably requires much longer to skilfully and appropriately combine the two according to the demands of more and more difficult problems.

In order to assess the relative importance of cognitive and stimulus constraints on scanning strategies throughout childhood it was decided that a sentence/picture verification task would allow for the specification of both the task and the way it was communicated to the subject. The visual arrays against which the sentences were to be judged could be varied so that perceptual and cognitive constraints would be in conflict if an efficient search was to be carried out.

With adults, this type of task seemed to provide one of the most satisfactory ways of gauging the effect of cognitive needs on search strategies and of studying the search strategies so generated, which provide insight into the interpretations attributed to the sentences being judged. Since the years between 5 and 7 years, and 12 and 14 years seem to be important transition periods in linguistic development and to correspond to periods of important general cognitive changes, it was decided, for these studies, to select children between 4 and 5 years, 7 and 10 years, 12 and 16 years and where possible to compare their performance with that of adults. The general design of these studies will be given in the next chapter.

CHAPTER 2

Experimental Task Used in the Eye Movement Studies and the Factors Influencing Its Design

This chapter will be concerned with presenting a general outline of the kind of task used throughout the eye movement studies and the factors which were taken into account in terms of the general design of this task. The apparatus used, the subjects selected and the general instructions given, have been described.

The eye movement experiments were intended to investigate the extent to which linguistic and perceptual factors would influence the way in which subjects of various ages searched visual arrays in order to judge the truth or falsity of statements made about the arrays. There was good reason to suspect that children would be more susceptible to perceptual than linguistic and cognitive factors.

2.1. Task. The task for the subject involved sitting at a large covered wooden box (35" deep x 39" wide x 19½" high) looking with one eye through a peep-hole placed in the centre of one side of the box. From the peep-hole the subject had a clear view of the inside face of the opposite side of the box, around the edge of which were arranged four 240-250 voltage, 60 watt strip lights. Diagram 2.1 shows the way the experimental situation was arranged. Prior to the commencement of each trial both the room and box lights were extinguished. so that the visual arrays could be positioned along the back of the box, without being seen by the subject.

Diagram 2.1. Experimental Set-up: Viewing Box seen without Lid and Camera.

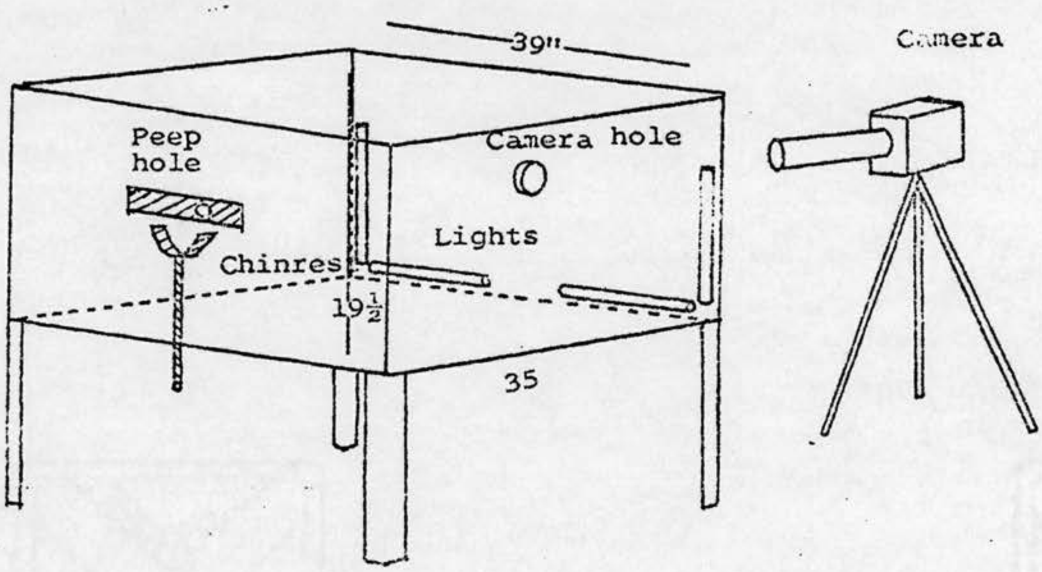
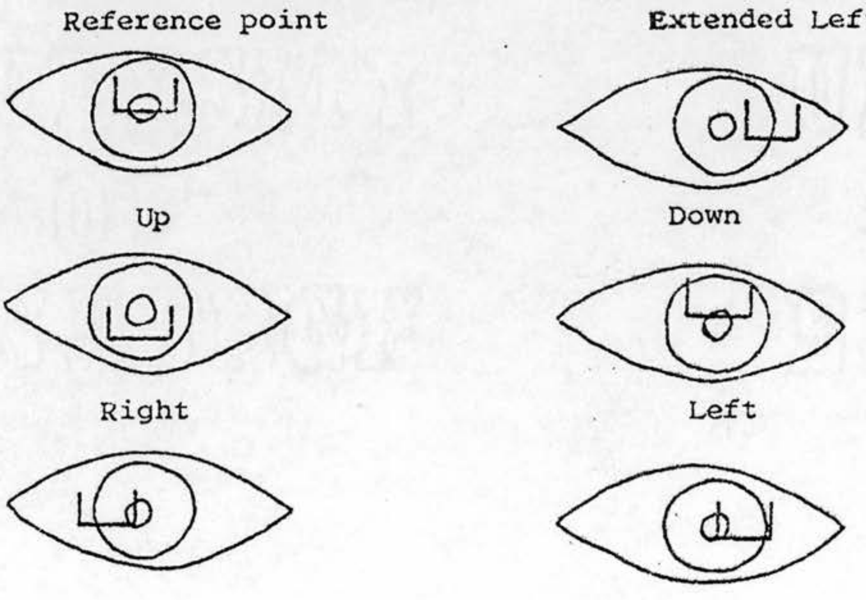


Diagram 2.2. Displacement of Light Reflections on the Eye when an Eye Movement is Made in a Given Direction.



The subject held a small button in each hand, one of which made a noise signalling a judgement of 'true' or 'right' and the other 'false' or 'wrong'. The experimenter then made a statement about the visual array that was to be presented, repeated it and asked the subject to fixate a green fluorescent spot (subtending 1° visual angle) located at the centre of the visual field. This was to control the position of the first fixation and to try to ensure that the stimuli were impinging on the eye of every subject in the same way when the lights were turned on. The task for the subject was to look at the array in order to find out, as quickly as he could, if the statement was a true or false description of the array. The subject communicated his decision to the experimenter by pressing the appropriate button, which stopped the Advance Timer Counter (accurate to .01 seconds) which had been triggered by the onset of the lights. Meanwhile the subject's eye was being videotaped by means of a telephoto-lens (Solinger 250 mm 4.5 Telephoto lens with four extension tubes) arrangement with a camera viewing the subject's eye through a hole (subtending 3° 30' in diameter) located just below the centre of the back of the box. The lights formed a reflection on the eye ball which framed the point just above the hole where the luminous green spot was located. When, during the course of experimentation, it became impossible to obtain the luminous paint, the subject was asked to fixate the top of the camera hole instead. The lights framing the pupil were clearly displaced when the subject made the gross eye movements which were required to fixate the various pictures in the arrays. Diagram 2.2

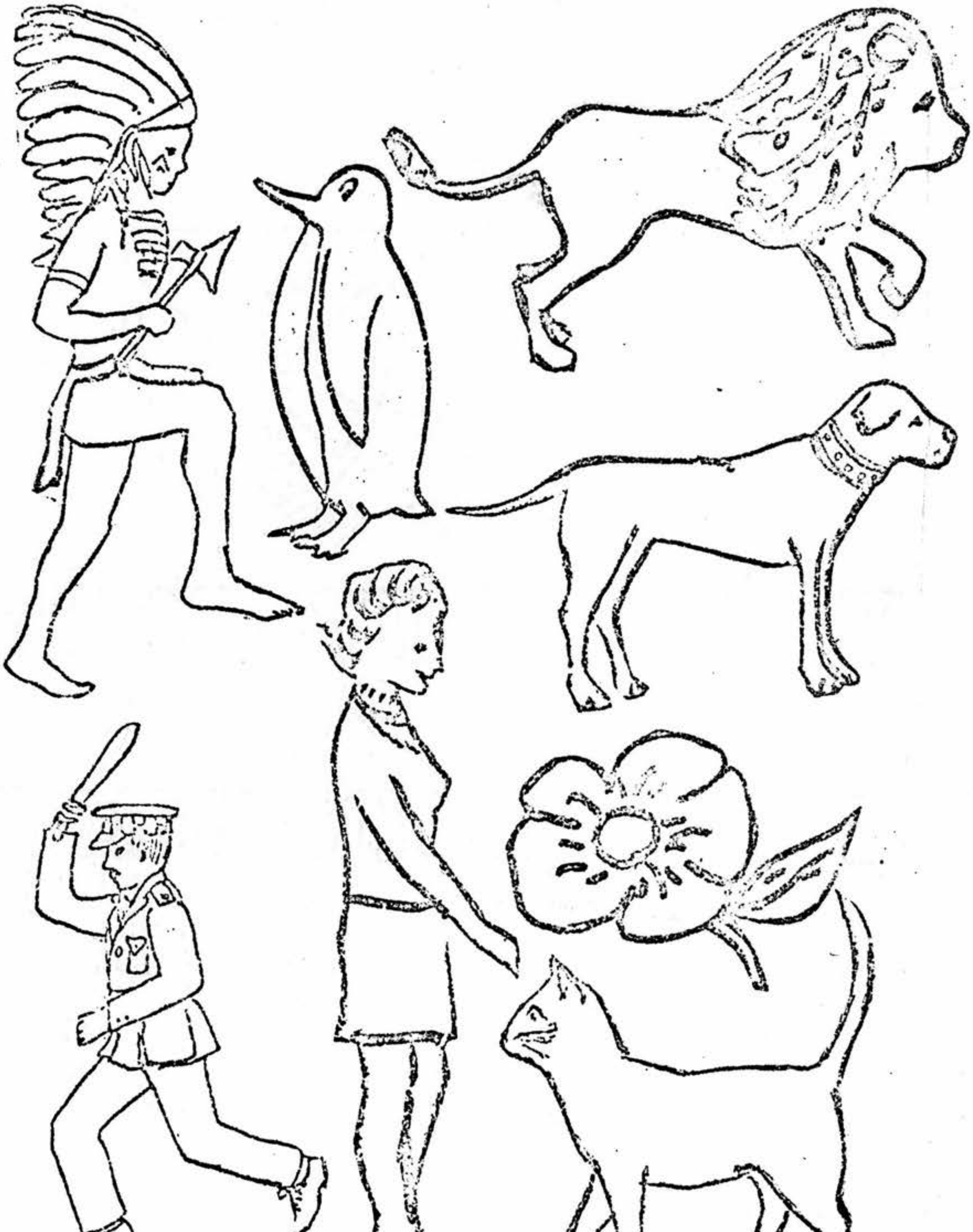
illustrates the nature of this displacement.

The specific arrays used in each experiment will be discussed in the chapters dealing with those experiments. However all arrays consisted of photocopies of black out-lined pictures which were pasted on to sheets of light grey paper identical to that which covered the side of the box occupying most of the visual field. These sheets were inserted into the box through a slit at the top of the box and were placed into position against the back of the box. Diagram 2.3 illustrates some of the pictures used.

2.2. Subjects. The youngest subjects were recruited from local Edinburgh nurseries. The experimenter visited the nursery, first familiarizing herself with the children and then individually engaging children older than 4 years in a selection test. This test was to ascertain which children could appropriately judge true and false sentences and signal this decision by pressing a bell-button for 'true' or 'right' and a buzzer-button for 'false' or 'wrong'. These buttons were small enough for the child to hold one in each hand and the youngest children were able to exert sufficient pressure to make a noise.

Pre-testing with nursery school children had shown that few children under four were able to correctly judge simple statements appropriately. Younger children tended to both fervently agree with patently false statements and firmly deny true statements. Those who could make appropriate judgements often found it difficult to signal their judgements with the correct buttons.

Diagram 2.3. Examples of Pictures used in the Experimental Tasks.



Children known to have poor eye-sight or to be left-handed were not used. Only naturally English speaking subjects were used.

For the selection test the child was given the following instructions:

> "We're going to play a game. I'm going to tell you some things. I want you to tell me when I say things that are right, when I say things that are wrong. Now listen ... (pause)... 'I think your name is --------'. Is that right or wrong?"

If the child said "It's (name) --------" the experimenter asked, "So was I wrong or was I right?." Several more statements were made, perhaps about the child's clothing or immediate surroundings and then the experimenter introduced the buttons to the child showing him how to press them and how each button made a different noise. The instructions continued

> "Now I'm going to tell you some more things. When I say something right, you have to press this button to tell me (presses bell). Don't tell me out loud, just press the button. When I say something that's wrong you press this button (presses buzzer) to tell me I'm wrong. Which one's for right? Which one's for wrong? Good. Now listen, 'I think --------'."

The experimenter continued making statements while urging the child to press the button as soon as he knew if the statement was right or wrong. If an apparently incorrect judgement was made the child was asked why the experimenter's statement was wrong. The child had to reach a criterion of eight correct false and eight correct true judgements out of twenty consecutive trials before proceeding to the next stage of the test. The child was then asked to judge statements made about which toy was to be produced out of a box by the experimenter. The experimenter said "I think you're going to see a ----" and then produced a toy within 30 seconds for the child to see. The child was given twenty such trials requiring 18 correct trials to reach criterion. Most children who reached the second stage were able to perform at criterion level. Performance was either very good or very bad. This second stage was to ensure that the children were capable of deferring judgement about linguistic statements until the visual evidence was available.

Nurseries varied in terms of the number of children found suitable for the eye movement study. Of those tested at seven nurseries the following percentages were found suitable; 89.1%, 85.7%, 83.3%, 78.6%, 77.8%, 70.6% and 50%.

The parents of those children found suitable were then contacted and asked if they were able to bring their child into the Psychology Department to take part in a study looking at how children look at pictures. Most parents were very co-operative and helpful.

Only two children, across all the eyemovement studies, became distressed when introduced to the testing room and asked to look into the box. Two children refused to continue after a rest break. Otherwise all children selected completed the test.

Older children were not given a selection test but given practice judging statements with the bell and buzzer prior to the experiment. Older children were contacted either through the nursery school subjects or by personal contact.

2.3. Experimental Procedure. The same procedure was followed for all the eye movement studies except for minor additions which will be mentioned when each study is dealt with.

All subjects were presented with the pictures to be used in the arrays and asked to name the pictures. This was to ensure that the subjects were familiar with the pictures. The child's label was used in the experiment. For the younger subjects the experiment was treated as a game and the subjects were not told that a video record was being made of their eye. A second adult, usually the child's mother, assisted the experimenter by keeping the child's head relatively still during the test trials. The "head-holder" stood behind the child and kept a hand gently cupped against the crown of the child's head to prevent the child leaning back during a trial and thus out of the camera range. The head-holder was able to monitor the child's eye movements on the video, as was the experimenter, and was also asked to check that the child had not changed the buttons from hand to hand during the course of the experiment. The head-holder was not to comment on the child's performance but to encourage him to justify his judgement if he seemed reluctant to speak. Subjects were permitted to move in between trials.

For subjects over about 6 or 7 years a head-holder was not necessary and the subject was simply asked to keep very still while they were looking inside the box. The older children, teenagers and adults were asked to take part in the experiment "in order to discover how much better older people were at doing the task than 4 year old children". The implied superiority seemed to reassure subjects about the strangeness of the task. Although the older children, teenagers and adults knew that a film was being taken of their eye this aspect was not emphasized and no undue interest was shown in it. Generally it was only teenagers and adults who were aware that their eye was being monitored during the experiment.

On being introduced to the testing room the subject was seated in front of the box and shown how to view the pictures placed against the inside back wall of the box by placing his chin in the chin-rest, his forehead against the forehead-rest and peering through the peep-hole. The buttons were placed in the same hands as in the practice trials and the subject asked to press each one according to the experimenter's instructions for further practice.

The room lights were extinguished and the door closed.

Still looking inside the box the subject was shown the camera hole (labelled "the hole") and shown the luminous green spot positioned just above the hole at H location (labelled "the spot"). The subject was told to stay very still while the lights inside the box were turned off. He was then informed that the experimenter was placing a picture against the back of the box. The experimenter then said:

"When the lights go on I think you're going to see a ----.When the lights go on you have to look and see if I was right or wrong. As soon as you know, press the button to tell me. I think you're going to see a ----. Look at the green spot (or hole)."

The lights were then turned on and the subject made his decision. If he pressed the "wrong" button the experimenter said:

"Mmm. Tell me why I'm wrong."

If the subject made an incorrect "right" decision the experimenter also tried to elicit the basis for his decision. The subject was then told that he had done it well and that other practice trials would follow so that he would get used to fixating the green spot prior to the onset of lights and would get quicker at finding out if the experimenter's statement was right or wrong.

After four or six practice trials, half of which were true and half false, which involved the identification of a single picture at B location, two practice trials were given where the subject had to verify a sentence against an array composed of two or more pictures. The video was then started. These two trials and the following test trials were presented in the following manner.

1. The subject was asked to look inside the box and the lights then extinguished.

2. The experimenter placed a picture at H and the experimenter said "This time I think you're going to see a ----, Look at the spot/hole. I think you're going to see a ----."

3. The lights were turned on, which onset the timer.

4. The subject made and signalled his decision which offset the timer. For the experimental identification trials the correct judgement was always 'right'.

5. The experimenter made reassuring but non-committal noises and where appropriate asked the subject the reason for his decision, while reading the timer and resetting it.

6. The picture was removed, the lights extinguished and the two or more picture array was positioned along the back of the box.

7. The experimenter said "This time I think - 'Test Sentence' -." The test sentence was repeated, the subject instructed to look at the spot or hole and the test sentence repeated.

8. The lights were onset and steps 4, 5, 6 and 7 of the procedure repeated.

All the steps were repeated for each trial throughout the experimental session except where specified in the individual experimental presentations. The subject was allowed to rest at appropriate points in the session or if the child showed signs of fatigue or disinterest.

2.4.1. Scoring. The experimenter inspected the video record of each subject's eye movements (EMs) noting the order in which the picture locations were fixated by the subject from the onset of the lights to the signalling of the subject's decision. Where the subject fixated a location within the visual array which was not marked by a picture in one of the labelled positions this was noted and the position of the fixation roughly assessed relative to the other picture locations. These eye movements were included in the count of the number of eye movements. It should be noted that a fixation was counted as occurring whenever a subject's eye rested for a discernable length of time at one location on the array. Since it was not possible to detect when the subject made eye movements to an area close to the previously fixated one or to a different part of the picture at the same location, the fixations were measured in this gross way and defined as the periods occurring between the observed large eye movements. These large eye movements do not refer to the relatively small eye movements which must have been made between various parts of the same picture during the recognition or identification process.

The eye movement record for each test item was noted along with the judgement time for that trial, the judgement made, the subject's justification of any 'false' judgements and any other relevant verbalizations made by the subject.

From the eye movement record the following measures could be taken for each subject

1. The appropriacy of the first eye movement as determined by the sentence and the spatial cues given by the first fixation picture (F.F.P.)
2. The number of eye movements (No. EMs) made.
3. The patterns of eye movements which could be specified as one of the following:
    i. an efficient search (ES) where the subject only fixated the relevant pictures but could make more

than fixation on the relevant pictures.

ii. a semi-efficient search (SES) where the subject fixated both relevant and irrelevant pictures but made more fixations on the relevant pictures,

iii. an inefficient search (NES1) where the subject fixated the relevant and irrelevant pictures an equal number of times,

iv. an inefficient search (NES2) where the subject fixated the irrelevant picture(s) more than the relevant picture.

The ability of the subject to maintain a fixation on H during the identification part of the trial was noted for those studies where it was relevant.

The ways in which reasons were scored and any additional scoring of the measures are described separately for each study.

The following decisions were adhered to when scoring subjects' performances in ambiguous situations. Where the subject changed his judgement by pressing first one and then the other button without making any additional fixations, the second judgement was accepted and the measures taken as for the first judgement. Where additional fixations were made before the second judgement was signalled, the additional time and eye movements were measured. Where the subject took longer than ten seconds to make a decision the trial was disqualified, as it seemed likely that the subject was likely to have forgotten the sentence. An attempt was made to repeat the trial or an equivalent version at the end of the experimental session if the trial was so disqualified or otherwise interrupted or rendered unacceptable for scoring. Where the subject's initial fixation was not on location H as instructed, it was scored as being an appropriate or inappropriate anticipation of the first eye movement (FEM). Where it was difficult to decide which location was the last fixated before a decision was signalled, the last location prior to the definite onset of the signalling noise was accepted as it was felt that the subject would have begun pressing slightly before the last uncertain fixation.

2.4.2. Reliability of Scoring: The ease of scoring the EM records was determined by the size of the angle through which the S moved the viewing eye in order to focus on first one and then another picture in the array. The size of the angle varied according to several factors which included the number and arrangement of pictures in the arrays used in the several studies, the size of the pictures used in any one experimental trial and which part of the first and second pictures were fixated immediately prior to and after the EM.

Arrays in the various studies consisted of either six, four, three, two or one picture locations. In the Quantifier Study the six pictures in the practice trial were arranged rectangularly and the four pictures in the test trials were arranged in a square. In the Top/Bottom Study the two pictures were arranged vertically while the four pictures were arranged in a diamond shape. In the Active/Passive Sentences Study and the In Front of/Behind Study the three pictures were arranged horizontally. All the arrays were arranged symmetrically about the initial fixation point at H. Depending upon the arrays, Ss could make horizontal, vertical or diagonal EMs in order to shift fixation from one picture to another.

The average size of the pictures used varied slightly (by a maximum of 2°) between, but not within trials, except for some trials in the Quantifier Study. For all except for the horizontally aligned arrays, the pictures were arranged so that the distance between the outer boundaries of the pictures remained constant which meant that slightly longer EMs were required to fixate between the nearest boundaries of pictures when the pictures were slightly smaller. For the horizontal arrays the distance from the centre of one picture to the centre of the adjacent picture remained constant.

The sizes of the average EMs between the various locations in the different arrays were estimated over the variously sized pictures and have been reported with the relevant studies. For the purposes of guaging the adequacy of the scoring procedure it should be noted that the average smallest vertical and smallest horizontal EMs which needed to be distinguished were of the order of 12° and the smallest diagonal EM subtended 17° 30'. Most EMs were in fact larger than this depending on the array and whether Ss moved between adjacent or non-adjacent pictures.

For each kind of array arrangement, the reliability of the scoring was checked by asking another viewer to make the same sort of EM records of the experimental sessions carried out by four of the Ss from the youngest group using that kind of array. The extent to which the records of each trial agreed with those of the experimenter (E) was estimated for the direction of the FEM, the number of EMs and the order in which they were made with each discrepancy counting as an error.

The records of the younges Ss were examined because it was these Ss who made the greatest number of EMs over the longest period of time and were most difficult to score in the opinion of the experimenter. It was felt that the scoring of the older Ss was at least as reliable or more reliable than that of the pre-school Ss. Table 2.1 gives the percentage of trials on which there was complete agreement with respect to each measure. Where there were discrepancies between the two records these tended to be small ones, where only one or two EMs had been overlooked.

Table 2.1

Percentages of Trials on which Scores of Two Viewers Completely Agreed with Respect to Each Measure.

Arrays			Measures		
Study	No.Pictures	Shape of Array	Direction of FEMs	No. FEMs	Ordering of EMs.
Top/Bottom	2	Vertical	97.9	95.5	95.0
"	4	Diamond	97.3	98.3	97.7
Quantifiers	4	Square	98.7	96.8	96.3
"	6	Rectangle	96.1	94.2	92.3
Active/ Passive	3	Horizontal	100.0	97.6	96.8

Confirmation of the high degree of accuracy possible with the scoring procedure. comes from Harris and MacFarlane (1974), who report that when two Es scored infants EMs, ranging in size from 40^{o} to less than 15^{o}, by means of observation through two peepholes, disagreements were less than 10% of the total number of observations for each subject. One would expect scoring to be even more reliable when video records were available for replaying and in fact most of the discrepancies which arose in the experiments to be discussed, were resolved in favour of the more experienced scorer when the relevant parts of the tapes were replayed frame by frame. The discrepancies arose mainly when the Ss continued to make an EM during a blink, or else when the S made a large number of rapid EMs between several picture locations, or when Ss referred back to the H position in between fixations of the pictures.

2.5. Analyses Those analyses which were carried out on all the studies will now be discussed. Analyses that were carried out for individual studies will be discussed as part of these studies.

2.5.1. Comparison of True and False Test Items. Not all models of sentence-picture verification processing agree on how to account for the effects on performance of the truth function of a sentence when the sentence is applied as a description of a certain picture. Clark (1970), Clark and Chase (1972) and Trabasso (1970) and Trabasso, Rollins and Shaughnessy (1971) have presented similar models to account for the judgement process, both Clark and Trabasso developing one model for the situation (A) where the sentence is presented first, then the picture, and another model for the reverse situation (B).

These models describe the verification process as consisting of a number of separate and ordered stages. Initially, they assumed that both the sentence and the picture were encoded independently in some abstract but common form of representation and that these representations were then compared in particular ways. Reaction time studies using simple two term binary situations, were carried out to specify the parameters which determine the stages through which the verification process must pass for a variety of sentence-picture combinations. The falsification time parameter was identified as the increment of time required to find a mismatch between the representations of the sentence and the picture, whether the mismatch is located in the basic descriptions given in prepositional form or in any additional qualifications appended to these descriptions. Time is also required to change the state of the truth index (which is assumed to be initially set at true) every time a mismatch is found.

However even positing such a model for the B situation is inappropriate in several respects. As Donaldson (1974) points out, it is incorrect to assume that the sentence and picture are necessarily independently processed. Since it is language which is judged of the world, it is not until the sentence is to some extent processed that the appropriate aspect can be selected from the real world or memory to be further represented in the abstract form common to both sentence and picture. With the very simple sentences and arrays used by Clark and Chase (1972), and with knowledge of the kinds of sentences being used, it was not unlikely that the adult subjects represented the pictures appropriately before hearing the sentence to be judged. But had more complex unpredictable sentences been used the subject would have had no way of independently representing the picture in a relevant way until he had processed the sentence.

In his model to account for the performance of subjects judging a sentence in an A-type situation, Clark does acknowledge that picture encoding is contingent in some general way on sentence encoding, saying (Clark and Chase, 1972, p.478) that "While the subject is holding the sentence representation in temporary memory, he must encode the picture in the same general format." In fact he states (Clark, Carpenter and Just, 1972,p.20) that various experiments have shown that "the inducement to code the pictures contingent on the sentences was apparently so powerful that it overrode the a priori coding preferences." However, even in the model meant to deal with the A-type situation, it is still assumed that the picture is given a full abstract propositional representation, rather than the picture being selectively interrogated in terms of the sentence. Since Chase and Clark (1971,p.311) have elsewhere assumed, with reference to the verification of above/below sentences, that "the direction of scanning will depend on specific requirements of the task," why do they not allow that the sentence to be judged could specifically and selectively guide the search of the picture and the ongoing construction of the picture representation? And if this was possible, why could the sentence representation be sometimes directly mapped onto the picture and matches and mismatches detected as they occurred? Differences in the times taken to judge affirmative and negative sentences, and in the interaction of negation and truth value may be accountable for in terms of other factors such as the ease of directly interrogating arrays given certain sentences and the expectations and presuppositions of the subjects.

The binary nature of the false truth value as used by Clark and Chase also has misleading implications for his model. With only two pictures in a binary arrangement a mismatch may take longer to detect and represent, but if a larger number of aspects of the abstract representations are to be compared then it is possible that a mismatch may take less time to establish than a match. This is a point made by Glucksberg, Trabasso and Wald (1973) who offer a variety of modifications to the models discussed, although they do not query the independence of sentence and picture processing. However, they do suggest that the extent to which the representations of the sentence and the picture are fully compared depends upon the nature of the mismatch between the two. On the basis of their verification time results, which were obtained for active and passive sentences, they suggest that sentence and picture representations are compared in terms of a propositional list structure with verbs being checked first, then the grammatical subject and then the grammatical object, surface order being observed for the comparison of the semantic agent and patient. Glucksberg et al proposed that voice information was not utilized at all (although presumably it was available) unless all the components of the list structures matched. They assumed that "processing would self-terminate on a mismatch between any pair of encoded constituents" and indeed found that for the sentence-then-picture presentation order, the false sentences had shorter verification latencies than true sentences when either the verb or grammatical subject was the sentence constituent false of the picture. But when the grammatical object was the falsifying constituent little difference was found between the latencies for true and false sentences. No explanation was offered as to why a mismatch on the grammatical object should take as much time as an additional comparison of a voice information.

Slobin (1966),who examined the development of the process of comparing active and passive sentences against pictures, found that the truth function of affirmative sentences alone had no significant effect on judgement times. All five age groups studied showed the same order of difficulty,with true affirmative actives and passives being easier than false. Significant differences between true and false sentences were only found for negative sentences, with false negatives being easier than true negatives to verify. However as Slobin used false affirmative sentences that were false of the pictures in a binary way, these findings do not refute the Glucksberg et al position.

Nonetheless Glucksberg does require more evidence to justify the assumption that people will perform in accordance with the self-termination aspect of the model. The poor ability of people to recognize disconfirming evidence has often been commented upon (Johnson-Laird, 1970). In addition, the anomaly of the grammatical object mismatch taking as long as a comparison involving an additional voice match, needs to be resolved. Moreover, since Slobin limited his affirmative sentence-picture mismatches to binary situations, further investigation is needed of the developmental acquisition of the process of examining the world in ways influenced by linguistic descriptions of the world.

It is for these reasons that true and binary or non-binary false trials were compared in the eye movement studies. These comparisons were made not only in terms of judgements and reaction times, but also in terms of the ability of subjects of varying ages to selectively seek out information in order to judge the sentences and their ability to terminate their search after finding the relevant information.

2.5.2. Comparisons Concerning the Location of Spatial Preferences. Various studies have suggested that people have physiological and previously learned tendencies to search their visual world in particular ways. It was decided to investigate whether these tendencies would override or interact with the constraints imposed by the sentence verification task. As well as discussing the particular spatial location comparisons made in different eye movement studies, evidence for the existence of these tendencies will be considered.

Upward Versus Downward Eye Movements

Clark, Carpenter and Just (1972) argue that the biological and geometric structing of our perceptual space has important implications for the way we structure that space linguistically. They propose that since our space is structured upward from ground level and forward from the perceiver people prefer to code the locations of objects positively, where upwardness and forwardness are positive directions, other things being equal. The results of a series of experiments by Clark and Chase (1972) using array descriptions sentence verification tasks supported this contention. Clark (1971) also presents some evidence that the order of acquisition of spatial and temporal linguistic terms is as one would expect from such a formulation. From the time of the infant's first visually directed movements 'up' or 'above' and 'front' are seen as being the normative directions for human beings. Clark (1971) suggests that the spatial terms representing these normative directions have different lexical properties than their opposites, which are represented by the less complex normative term plus some marking of the opposition aspect. Asymmetries in reaction times between sentences using 'above' and 'below' or 'front' and 'back' are seen as reflecting the ease of coding the different semantic status of the less semantically complex unmarked terms as compared to the more complex marked terms. However reaction time experiments do not permit the separation of such factors as the difficulty in processing the linguistic term and the difficulty of carrying out a visual search in a certain direction.

Levy-Schoen and Pouthas (1971) did indeed find a significant tendency for 3 and 5 year olds as well as adults to first fixate the upper figure of a two picture array each of which was equally distant from the initial fixation point along the vertical axis. However this was in a simple identification task with no linguistic constraints which might possibly order the direction of the fixations. It was therefore decided to examine the eye movement measures of performance on the top-bottom sentences to discover whether sentences requiring eye movements upwards from a central reference point were verified more efficiently than sentences requiring downward eye-movements. It was hoped to be able to separate out factors like the difficulty of linguistic processing and the difficulty of visual search.

Eye Movements to the 'Faced' versus 'Unfaced' Side

Since the objective space system is seen as evolving from the primitive body-space system, with the difference between 'front' and 'behind' terms deriving from the front part of the body being the side of action in the world, it was decided to ascertain whether the same preferences would be evident in the first eye movement preferences shown in those studies where subjects had to locate objects with reference to other fronted objects rather than to their own bodies. One of these studies explicitly required subjects to verify sentences by either making an eye movement to the 'front of' the FFP, or 'behind' the FFP. The Active/ Passive sentence verification study only implicitly required the subject to look to the faced side of the FFP. However both these studies can be regarded as requiring the subjects to extend their normal search patterns forward from themselves to a more generalized symbolic situation. Clark (1971) suggests that this search pattern forward from the self is reinforced by man's social habit of interacting in a "canonical encounter".

Scaife (1974, personal communication) has found that some infants as young as 4 months and most infants at 12 months are able to look along the line of sight or locomotion of an adult, presumably in order to focus on an object of common interest. It may be that this habit becomes so overlearned that it carries over into the higher order task of looking at pictorial representations of animate or intrinsically "faced" objects.

Left v Right Eye Movements

Since no major physical asymmetrics occur in the case of the horizontal reference plane of the body, Clark does not postulate any perceptual reason for a preference for right or left when searching or describing space. Harris (1973), however, has argued that while body asymmetrics provide no reason to suppose that people will conceptualize space so that left or right constitutes the normative direction, the handedness of a person might act to mark one side as normative. To support this argument she compared the performance of right and left handed adult subjects on a task requiring them to draw one picture with respect to another given picture. The picture was to be drawn in accordance with instructions which specified which spatial relationship was to obtain - right, left, above or below. Both groups of subjects made more errors on 'below' than 'above' instructions but left-handers were better at placing pictures left of the given picture while right-handers showed the reverse preference. But this finding that handedness affects the absolute ability of people to place objects to the right or left of a fixed point, let alone affecting the degree of skill involved in the actual placement activity, does not rule out the need to check that directional differences also exist in terms of the visual system and the ability to place objects in terms of eye movements rather than with manual responses. In another manual task Wallington (1974) required children (3 - 5 years) and adults to select one of three boxes according to verbal information given by the experimenter. These boxes were arranged from left to right on a table in front of the subject. Control subjects made the selection without the verbal information. Both the experiment and control children showed a significant tendency to select the left-most box as the first response. However adults showed a slight but insignificant tendency to select the right most box.

In Levy-Schoen's (1971) study when eye movement preferences along the horizontal axis were examined, there was a slight but insignificant tendency for the 3 year olds and adult subjects to first fixate the left hand side of an array, but the 5 year olds showed a significant tendency to fixate the right-hand side first.

Lesèvre (1966) has found that with respect to horizontal eye movements there was a striking development in normal children between the ages of 6 and 12 years in the motor aspects of perceptual activity. This development was quite apart from any organization of the visual field in response to a recognition, comparison or evaluation task. This finding emerged from a study comparing the oculographic patterns of normal children with those of dyslectic children and others showing some degree of spatial disorganization. As well as differences between the various groups, Lesèvre found a development within the normal group, firstly in the speed with which the children could move their eyes to locate a point of light; secondly in the ability to successively fixate a series of small crosses distributed at random distances along successive even lines on a page, regardless of the direction imposed on the looking activity; and thirdly in the expression of a preference to look from left to right which appears between 7 and 8 years when no particular preference was apparent at age 6.

With reference to the last mentioned development Lesèvre asked whether ocular-motor reading habits may not, little by little, produce a selective training of the left visual sensorial cortex and thus a selectivity for stimuli appearing in right control and peripheral vision. However on these grounds one might also expect some right-lateralization to result from re-orienting the gaze to the left at the end of each line when reading. It is difficult to decide whether such a preference for one side of the visual field arises from reading activity or whether the readiness to begin reading stems from the emergence of an already existing predisposition to structure the world in the way expressed by the preference.

Miller's (1969a and 1973) findings are also pertinent. In one study (1973) subjects were required to locate which quadrant of a circular array (subtending 20° in diameter) contained a target letter. The two younger groups (mean ages 6;6 and 8;6 years) showed a better performance for targets appearing on the right-hand side of the array, while the two older groups, (mean age 12;6 and adults) did not show such a preference. The preference of the younger groups was strongest when the target fell within 1° of the centre of the field, less strong at 5° from the centre and non-existent at 9°. The preference was more likely to appear on the trials with the shorter exposure durations for the three youngest groups. The findings were consistent with the view that age differences in scanning speed, together with a strategy of searching from the centre out in a right then left direction, produced the differences observed.

The studies discussed so far allowed subjects to use both eyes for viewing. For technical reasons only one eye was used for viewing in the eye movement studies being presented although it was assumed that both eyes moved conjugately. Relevant to this aspect of the experimental task, is a study by Crovitz and Daves (1962) where adults used either their right or left eyes or both eyes for viewing arrays consisting of a numeral at 3°, 5° and 7° right and left of a fixation point. These arrays were presented tachistoscopically for 100 milliseconds and the first EM made after the presentation was recorded electro-oculographically. Crovitz and Daves found a congruence between the direction of the initial EM after the presentation of the array and the side of the visual field more accurately reported. They also found that under monocular viewing conditions there was a greater tendency to make an EM to the side of the viewing eye. This suggests that for the left eye the left half of the visual field is more accurately seen and for the right eye, the right side is more accurately seen. However it is not possible to determine whether the motor tendency to look in a given direction affected the visual accuity of the eye in a certain way or whether greater acuity for a certain part of the visual field led to an EM in that direction. In the 1969a study where the same task was employed but with a visual field subtending an angle of 5° and with fairly short exposure durations, all age groups (mean ages 8.0, 11.9 and 20.2 years) gave superior performances when locating a target on the right-hand side of the field. However as the fields used in these studies consisted of letters arranged homogeneously or in a circular manner about the initial fixation point, linear horizontal scanning of the array was not compulsory and in this respect the situations differ from the other tasks discussed.

In view of the conflicting evidence from hand and eye movement studies it was decided to examine the eye movement data to see if any preference for either the right or left was shown by any of the age groups.

Eye Movements to Adjacent versus Non-Adjacent Pictures

Both Olson (1970) and Wallington (1974) report that in manual search tasks young subjects tended to search from one location to an adjacent rather than a non-adjacent location. Mackworth and Bruner (1970) note that when inspecting clearly focussed pictures children made twice as many very short eye movements (of 1° or less) than adults, and they tended to concentrate their gaze on a small visual area. This finding is explained in terms of the difficulty young children seem to have in combining information coming from the centre and the periphery of the visual field. Instead of using peripheral information as a basis for constructing an integrated perceptual field, the children's useful field of view may be reduced so as to prevent the overloading of the visual system.

In order to provide some further evidence on this matter it was decided to analyse the eye movement records for the Active/Passive Study with respect to the number of EM's (excepting the first which was of experimental necessity of an adjacent nature) made between adjacent, and those made between non-adjacent pictures.

2.5.3. Comparisons Concerning the Effect of Irrelevant Information on the Development of Selective Attention. For Gibson(in press) perception involves the extraction of information from the world, and perceptual learning involves a modification of what is perceived rather than an increase in the scope of what it is possible to sense. From this point of view an increase of perceptual capacity with age implies a greater selectivity and further differentiation of information.

If one important aspect of the developmental process is to be described as an increasing ability to ignore irrelevant and process only wanted information, then it is necessary to discover for various age groups at what stage of processing the irrelevant information is distinguished and differentiated from the relevant: - that is to say whether the selection occurs before or after final perception. Questions must be answered as to whether irrelevant information is partially or totally attenuated by some filtering process or whether all information of the same sort is processed equally well and the information designated as relevant is then selected after the perceptual process is complete.

Several studies have found evidence to suggest that in the auditory, visual and kinaesthetic modalities, relevant information can be better attended to if selection is allowed to take place before final perception occurs although younger children are less proficient at this than older children. This lack of proficiency in the younger children might be due to either an inability to decide what is relevant information or else to a failure to apply a criterion of relevancy to guide processing. The studies which will now be discussed point to the latter as being a major consideration in the ability of young children to ignore irrelevant information.

Pick et al (1972) asked two groups of children (2nd and 6th grade, about 6.0 to 11 years) to judge whether a pair of animals which could vary in shape, colour and size, were the same in some specified way. All children made the judgement under two conditions. The first specified the aspect of the objects to be compared before the objects were presented while in the second condition the child viewed the object and only then was he told which was the relevant aspect for comparison. They found that the older children were better able than younger children to use the information about the relevant aspect for comparison. However even the young children were able to perform more efficiently on 80% of the trials when they could select the relevant aspects of the objects for processing.

These results accord well with those of Maccoby (1971) who investigated age changes in selective attention in the auditory modality. She found that older children were able to perform better than younger children (age range: 5 - 12 years) under conditions where they had to process either both or one of two interwoven or simultaneous verbal messages. Little difference between the groups was found when only one message was presented. Thus the introduction of an irrelevant message interferred more severely with the performance of the younger than the older children, even though there was no change in the nature of the response required. However the younger subjects were able to improve their performance to more or less the same extent as the older subjects when they were signalled in advance which message was to be reported.

Maccoby supports the view that young children find exclusion difficult and cannot spontaneously take only the small amount of information necessary to specify the irrelevant part of a stimulus array. In her studies this was shown in the identification of the words rather than just the voice of the speaker. McNeill's (1971) view of the findings is that young children habitually record information before operating on it, using a "post-selection" strategy, while older children are more likely to select which information is allowed to be fully processed using a "pre-selection" strategy. McNeill argues that the first mode of processing may have special advantages for younger children in as much as it allows information to get into the system before being distorted by the selective process itself. Gibson also suggests that for the young child the optimal strategy may be to explore the world discovering critical features, which a strategy of rigid selectivity would not permit. Development must consist of the achievement of a balance between heightened attention to information required by task demands and some incidental exploration of other potential input.

Indeed, if incidental learning is regarded as a measure of the degree to which attention is not focussed, then the development process extends over a long time. Maccoby and Hagen (1965) and Siegal and Stevenson (1966) found an increase in the retention of irrelevant information from ages 7 to 11 years and then a decrease from ages 11 to 13 in their studies of visual incidental learning.

The same sort of picture emerges from several other studies. Nodine and Evans (1969) and Nodine and Laing (1971) found that 3rd grade children, while taking less time overall than kindergarten children in comparing two strings of 4 letters, spent more of the time focussing on the relevant rather than the irrelevant figures. In Lehrman's (1972) study the task for the subject was to match to a standard one of a pair of objects which differed in shape or texture. Both the objects were out of sight and had to be explored tactually, while the sort of hand movement made was noted. Children from all the age groups (5, 6 and 8 years) were better able to search appropriately when told which aspect of the objects was to be compared with the standard. However when not given the preparatory signal the youngest group showed no ability to ignore the irrelevant feature, while the second graders improved on the texture problems but not on the shape problems. Only the 8 year olds showed an ability to ignore whichever feature was irrelevant and even they were not perfect. As Pick et al (1972) found certain variables are easier to ignore than others, shape being easier than colour or texture.

From all these studies the general picture emerges of young children as being to a certain extent capable of attending to some kinds of information which have been explicitly designated as relevant. However they still have some way to go before they are able to determine what is relevant for themselves and then use that information to guide their subsequent selection of information efficiently.

But in all these studies it was the case that the two aspects of a stimulus situation to be distinguished were so confounded that it would have been impossible to totally exclude the processing of one, at least at the peripheral levels. It may have been that the younger children were 'captured' by both aspects when they were interdependent, but the question still remains as to whether the younger child can ignore irrelevant information that is more divorced from the relevant information.

The eye movement studies provided an opportunity to attempt some sort of answer to this question of whether the younger child's failure to focus on relevant information was due to being passively caught by various features of the stimulus array or whether it was because the child actively sought out irrelevant information as part of a general strategy of visual search.

The EM studies also provided an opportunity to vary amount of distracting information in a quantitative way. In the Top/Bottom studies 1 or 3 irrelevant pictures were presented to the subject and the amount of attention paid to them in terms of number of EMs was observed for the different age groups. The effects of irrelevant information located along both the vertical and the horizontal axes was studied. The effect of redundant information was studied in the 'All' and 'None' study.

2.6. General Design Factors: Factors which had to be taken into account in the design of the eye movement studies will now be discussed.

2.6.1. Viewing Eye. In the studies requiring any horizontal

EMs half the subjects viewed the arrays with the right eye, and half viewed with the left eye. This was to study any tendency for the subjects to fixate the picture on the same side of location B as the viewing eye, there being more visual space unobstructed by the nose on the right side for the right eye and on the left side for the left eye.

In the studies requiring vertical EMs all subjects viewed the arrays with the right eye.

2.6.2. Signalling Judgements. Half of the subjects in each experimental condition signalled correct or 'right' judgements with the right hand and incorrect or 'wrong' judgements with the left hand. The reverse situation obtained for the other half of the subjects. This was to ensure that for the true/false comparison, measures of performance would not differ because of the hand being used to press the button or the operation of any 'Stroop' effect.

2.6.3. Visibility of Pictures Viewed in the Dark. To ensure that the subjects were unable to begin the verification process until the onset of the lights, the experimental procedure was carried out with eight 4 year olds, eight older children and eight adults, who were asked to identify the three pictures in each of four horizontal arrays and four vertical arrays, while the box was in darkness. The set of pictures from which the arrays were selected were shown to the subject prior to the experimental trials. Before each trial the lights were turned off, the array placed in the box, the subject asked to look inside the box for 45 seconds and then asked for the identity of the objects. The lights were turned on between each trial.

None of the subjects correctly identified any of the pictures. The youngest children were unwilling to even guess the identity of the pictures. Where subjects were given additional arrays and asked "Is there a ---?" being given the correct identity half the time and an incorrect identity half the time, correct selection was not above chance level.

2.6.4. The Identification of Images Falling on the Retinal Periphery. The pictures making up the visual arrays in the present studies had to be sufficiently separated in space not only for scoring purposes, but also for the following reason. The aim of the experiments was to specify whether "attention", in the form of visual searches, could be constrained in a very precise way by the linguistic information to be verified or whether it was constrained by either general or specific perceptual biases. Thus it was necessary to ensure that the direction in which the subject had to search could only be inferred from a combination of the linguistic information and knowledge of either the orientation of the first fixated picture or its position within a larger frame of reference. However, if it was possible for subjects to direct their eye movements appropriately on the basis of information derived from peripheral stimuli, then only a weaker sort of linguistic constraint could be said to be operating. In this case the subject would be seeking out the pictures referred to in the sentences but not by inferring their locations from the linguistic information.

Because it has been taken for granted that precise information is only available from areas that are being directly fixated, many experiments have taken eye fixations as indicators of the distribution of attention. But there is no definite agreement as to how much information can be gained from the periphery under a variety of conditions. Indeed, defining what constitutes peripheral vision is not a clear-cut process. Most research supports the notion of a structural and functional continuum from the fovea to the extreme periphery. It is difficult to assess the relevance for the present studies of that information which is available about the ability of viewers to identify objects whose images fall at varying degrees of eccentricity from the fovea. In the present experiments it was usually the case that the images of two or more meaningful pictures fell at an equal distance from the fovea, although in different quadrants. In the meantime the subject was either fixating part of another meaningful picture or the luminous spot. Moreover, in one of the studies requiring horizontal eye movements, the images of the two pictures fell 13-19^{o} from the fovea along the horizontal meridian, one in the temporal field and one in the nasal field. This meant that one picture fell partially on the blind spot, but since the placement of the appropriate picture and the viewing eye of the subject were counterbalanced across the experimental condition it was not expected this would affect the results. Each of the studies that will now be reviewed has implications only for particular aspects of the experimental arrangements, but it is hoped that more light will be cast than shadows thrown by a fuller consideration of these aspects.

Studies of visual acuity (Weymouth 1958) have shown that visual acuity falls off very rapidly away from the fovea, corresponding to the large reduction of the frequency of cone receptor cells within 5-10^{o} of the centre of the fovea, and the absence of receptor cells in the "blind spot". Lakowski and Aspinall (1969) studied by perimetric methods the retinal sensitivity (to a spot of light) of five children (aged from 6 to 11 years) as well as the sensitivity of young adults. They found that the younger the subject the less sensitivity there was both at the fovea and in the periphery. The visual field along the horizontal meridian extended up to 15^{o} on either side of the fovea for the 6 year old subject and this gradually increased up to about 50^{o}eccentricity at 11 years which approximated the adult field. Unfortunately retinal sensitivity along the vertical dimension was not studied so it was not possible to ascertain whether the visual field was similarly reduced along this dimension for young children. As the visual system should be physiologically capable of dealing with a light stimulus by six years. Lakowski and Aspinall speculated that the lower sensitivity of young retinas may be due to the inability of children to deal with peripheral information or else due to the cortical suppression of peripheral information so as to allow perceptual development to take place in the foveal area.

Aspinall (personal communication) has carried out a second series of experiments in an attempt to reconcile

Liao's (1973) findings, which supported his own, with Allan's findings, which did not. He found that the extent to which the retinal threshold gradient was higher for children from 6 to 11 years than adults depended on the particular conditions under which the perimetric assessment was carried out. When children were rewarded with a sweet for identifying the presence of the point of light the constriction of their visual field was not nearly so marked, which suggests that changes in visual acuity may be accounted for by changes in the level of the response criterion. When response criterion effects were removed by using a forced-choice response measure, differences between adults' and childrens' peripheral thresholds were greatly reduced as was also the case when foreknowledge of the position of the light was given to the subjects. In contrast to the situation where foreknowledge of the one location was given, the difference between children and adults was accentuated when there were two possible locations.

Aspinall was inclined to reject any explanation of the threshold differences that was based on a maturation defect of the visual system, especially central vision, although he did not rule out the possibility. Rather, he argued that response effects account for much of the difference found although a significant residual effect may be due to the children's inability to attend to more than location in peripheral vision. He implies that even attending to the red spot used as a fixation point may sufficiently occupy the child's attention that he cannot divert his attention away from fixation point unless the field is highly structured by designating the peripheral location to be attended.

Sanders (1963) looked at the ability of adult subjects to compare the numbers of lights in two columns of lighted dots when fixating the left column. The amount of time required to compare the lights was a monotonically increasing function of the degrees of separation between the columns. Sanders noted that at the extremes of the stationary field (that observed without eye movements) subjects said they were judging on the basis of overall impressions rather than detecting the number of lights.

So in terms of thresholds for the detection of simple visual events the periphery seems much less efficient than the fovea. Early studies also generally agreed that rapid deterioration of identification performance was to be expected as a form was progressively viewed at greater degrees of eccentricity in any of the four retinal quadrants. However most of these studies required the subject to provide absolute identification of the form and no control over the subject's eye movement were made other than being monitored by the experimenter. Menzer and Thurmond (1970) looked at the accuracy with which either an outlined or solid polygon or histogram (subtending 10 - 14° visual angle) at up to 80° eccentricity along the horizontal meridian, could be identified. The eye movements were monitored electro-oculographically. The subject had to match the target form, presented at one of six points on the periphery to one of three alternatives (subtending 2 - 3°) presented in a vertical manner at the fixation point. It was found that some forms"especially solid polygons"could be identified more accurately at greater degrees of eccentricity than had previously been allowed for.

Another aspect of objects which make their identification easier at peripheral locations is their redundancy. Antes and Edwards (1973) found that redundant 5-dot patterns (subtending 2° 50' visual angle) were easier to identify at all peripheral angles up to 30° than non-redundant or intermediate patterns. Subjects had to indicate their identification of a pattern by filling in the dots on a 3 by 3 matrix. The experimenters admit this procedure may have inflated the recognition score on redundant forms as it has been claimed that subjects tend to spontaneously produce patterns of greater redundancy. However the same basic pattern of results was maintained, although with smaller angles of separation, when a same-different matching task was performed by the subject comparing on stimulus at the fovea and one at 7° eccentricity on the periphery. Here only the redundant patterns were correctly identified ai beyond chance levels at 7°. The pattern on the fovea did not affect the performance, the discrimination seemingly being determined by the information load on the periphery. Other studies (Taylor, 1969) have found an increment of the eye-coice span in reading tasks with increasing redundancy of the material to be read.

Sanders, Webb and Baker, (1955) observed that when

subjects were viewing a series of dials they appeared to be able to take in more information than might have been expected from peripheral vision, provided they had some expectations about what they might see. Sanders (1963) also studied this factor of knowledge of the information to be sought from peripheral vision. Again subjects were to compare the numbers of lights in two columns separated by a varying number of degrees, but the column seen in peripheral vision was extinguished at time intervals ranging from those allowing for no eye movements to those where an eye movement could begin. From the results it seemed that some information was obtained even during eye movements but the confidence ratings of the observers was low and their performance poor at the greater degrees of separation.

Grindly and Townsend (1968) found that subjects seemed to be able to voluntarily direct their attention within visual fields subtending up to 20° by 20° at the eye without making detectable eye movements. Thus, there is some evidence that under particular conditions peripheral vision can provide some useful information. These particular conditions may vary with the size, intensity, colour and position of the stimuli to be viewed. The effect of the position of the stimulus to be viewed within the visual field is one condition that has received some attention. As early as 1923 Dallenbach reported that there were "gradients of importance" in the visual field and while early studies might have lacked some desirable controls, more recent studies, some of which have already been discussed, have supported the idea that the left-hand side and top of the visual field have priority for information processing even though these areas are not known to correspond to any non-homogeneities of the retina itself. Payne (1967) found that when subjects were presented with stimuli at various points on a circle around the fovea and at 15° from the fovea, their reaction times were fastest when locating stimuli in the regions 90° to 180° and 300° to 20° from the vertical reading in a clockwise direction. Reaction times were slowest in the regions of 40° to 220°.

So far most of the studies discussed have been concerned with the performance of adult subjects on tasks explicitly requiring them to extract information from stimuli falling on the periphery while fixating another stimulus. What of children? How well do they fare when required to monitor or use peripheral information that is well within their range of visual acuity?

Mackworth (1967), Mackworth and Bruner (1971) and Piaget and Vinh Bang (1961) all found that children tended to restrict their attention to the centre of their visual fields. Piaget discusses his observation that children attend to relatively few parts of visual field in terms of his concept of centration, which refers to the general difficulty of children in overcoming or neutralizing perceptual distortions found in single fixations through active visual search. Mackworth discusses the shorter interfixation distances and the greater concentrations of fixations found in children's EM records in terms of a kind of tunnel vision which suggests that peripheral vision is not just attenuated but blocked by the processing of a certain amount of information from foveal vision.

Mackworth argues that compared to the adult, less visual information is required to overload the child's visual system and to bring about a contraction of the useful field of view by a blocking of information from the peripheral visual field. Even with adults Mackworth (1965) found that pattern recognition or matching under tachistoscopic conditions was severely impaired by the addition of irrelevant information. This was especially the case when the stimuli to be matched were separated by more than 2°, whether embedded in a line of 17 letters or a page of 374 letters. Even the introduction of two 'noisy' letters, placed outside the wanted letters, was sufficient to reduce recognition scores of the wanted letters.

Although visual noise seems to reduce the size of the visual field, Williams (1966) showed that it was possible for adults to search a visual field in a structured way provided the target object was specified in some way. The visual fields in question subtended 39° by 39° and contained 100 stimuli which differed widely in terms of size, colour and shape. The target object was specified as a given numeral embedded in a shape. It was most quickly found if specified by colour and size, then colour, size and shape and then colour and shape and then colour. Colour was the best single characteristic for guiding search, then size and then shape which provided little help in guiding the EMs, which were measured using a corneal reflection technique. The results are not surprising considering the distinctions best made by the rods in the periphery. Williams proposed that the specification of a target created a perceptual structure which the viewer explored. Though not ruled out by the results, Williams does not support the hypothesis that the decision of where to direct each EM is made completely during the previous fixation.

These studies raise the problem of whether the 'centration effects' are due to either (1) the size of the effective field of view taken in by a single fixation which might be due to the rate of processing of foveal information or else to poor retinal acuity in peripheral areas, (2) the ability of the child to direct his eye movements according to whatever information is coming in from the periphery and the centre during the single fixation, i.e., his ability to carry out parallel processing, (3) or a combination of both. Adult studies have shown that parallel processing of visual information is possible for adults. Mackworth and Morandi (1967) found that adults were able to direct their eye movements to those areas of a fairly large array (16° by 16°) defined as most informative by means of an independent assessment.

The discussion will now proceed to review some of those studies which have attempted to resolve the problem of the causes of children's poor peripheral vision. Most of the studies have employed tachistoscopic presentations of stimuli in order to study the extent of the visual field for a single fixation. Marshall, Haith, Morrison and Sheingold (1970) reported only minor age differences between 5 year olds and adults in the amount of information processed during the tachistoscopic presentation of single geometrically shaped stimulus, subtending 33' of visual angle at the centre or up to 3^{o} off centre of the visual field. The only exposure durations to produce large age differences were those of 5 and 10 milliseconds, with only small differences occurring at exposure of 20, 30 or 40 milliseconds. It was concluded that differences in visual information processing were due to differences in visual scanning strategies rather than the internal processing of stimulus input. Haith (1971) reported further studies in which either 1, 2, 3 or 4 stimuli were presented tachistoscopically to children and adults, with exposure durations that permitted no EMs. In contrast to the single-stimulus situation, the children were extremely poor in reporting more than 1 of 4 items, whether or not 2, 3, or 4 had been presented. In order to ascertain whether this poor performance was the result of slow-processing of a long-lasting 'trace' or 'icon' of the array (which would result in good performance with a single stimulus but a hold-up in processing any more than one) Liss and Haith (1970) used a visual mask presented at various intervals after the stimulus to map the course of visual processing. They found no evidence to suggest faster visual processing of a single stimulus occurred with increasing age. However when processing of multiple stimuli was required as in Sheingold's (1973) study, children's performance deteriorated more markedly than adults' the longer they had to hold the information in memory before processing it. Arrays containing eight stimuli were presented tachistoscopically with a marker occurring at some time up to a second after the end of the presentation so as to indicate which stimulus was to be reported. As mentioned before, Haith (1971) concluded that children as young as five are fairly rapid and efficient information processors with single and even multiple stimuli which are available for a single fixation, provided that a strategy for dealing with the stimuli is imposed within 150 milliseconds of the offset of the visual array. But where he has to provide his own strategy for retaining information the younger child experiences difficulty.

While the results of these tachistoscopic studies must be taken into account when considering the development of strategies for dealing with visual information, the scope of their implications is limited to small visual fields (Sheingold's subtended $1^{\circ}20'$) that are available to the subject for only a single fixation. Gibson (1966) has argued that tachistoscopic recognition studies do not provide a reasonable picture of the processes at work during most visual search tasks, which may require abilities other than that of recognizing partial or degraded material. Nor have these studies controlled the initial fixation point of the subject beyond asking him to fixate a specified area. If younger children were more likely to shift their initial fixation point, some of the poor performances of young children may be due to the fact that parts of the visual field were not symmetrically distributed around the fixation point.

Ideally the extent of the visual field at various ages needs to be studied in a situation where the target stimulus is part of a large array and impinges on the periphery of the eye for periods of time longer than that required for one eye movement. McConike has developed a measuring devise which detects the directions of iminent eye movements by electro-oculographic means sufficiently early for the computer controlled stimulus array to be rearranged so that the target stimulus always remains on the periphery. As yet only reading materials have been used as the stimulus arrays and the extent of the visual field as indicated by the eye-voice span has been of the order of several syllables. But pictorial arrays are more familiar and basic to all subjects and deserve consideration in their own right.

A vain attempt was made to find out whether subjects could identify a picture whose image fell on periphery during a prolonged fixation of another picture or reference point. However given this task the subjects, especially the younger ones found it impossible not to shift fixation points between the first and second picture. Moray (1969) noted that Sanders found it extremely difficult to train observers to refrain from shifting their gaze from one column of lights to another until they had finished a response to the first fixated column. The natural strategy seemed to be to respond in terms of an ongoing visual search. However Piaget and Vinh Bang (1961) found no developmental differences in the ease with which children were able to maintain a fixation point. This discrepancy in results may possibly be explained in various ways. Perhaps in a relatively familiar visual array, blank except for two interesting pictures, these pictures proved so distracting that they caused large "leaping" EMs whereas in Piaget's experiments the line stimuli were not sufficiently intrinsically interesting to overcome the effect of "centred" visual search.

To return from the ideal to the real, one finds a number of developmental studies by Miller, which have looked at search strategies in a task where the subject was required to identify in which quadrant of a visual field a target letter occurred. An early study (1969a) found no differences between groups of subjects (mean ages 8.0, 11.9 and 20.2 years) when small visual fields of 3° or 5° were presented tachistoscopically for presentation durations sufficiently small to prevent eye movements. Decrements in performance were found for targets in the periphery of the 5° field. A more recent study (1973) enlarged upon the earlier experiment, so that the subjects had to locate the quadrant containing the target letter from a display which subtended 20° from the subject's point of view and contained 400 non-target letters arranged in a homogeneous manner. The subject started by fixating the centre of the display and the targets were located either 1°, 5° or 9° from the centre and equally distributed over the four quadrants. The performances of four age groups (mean ages 5, 8.5, 11.5 and 19 years) were studied for exposure durations which varied from 250 to 2000 milliseconds. Age differences were found under those conditions where scanning strategies could be employed, or in other words, as the exposure duration increased and as target distance from the centre increased. Miller (1969b) also found a group of children (mean age 8.0 years) had a much longer latency than adults in moving their eyes through 13^{o} to a more distant light stimulus than in moving their eyes through 6^{o}. This was taken to indicate that differences in the ability to use peripheral information to direct active search involved the speed of oculographic latencies. Like Haith, Miller concluded that age differences in visual search performance over large fields were due to factors other than reduced visual acuity in the periphery.

In applying these conclusions to the design of the present eye movement studies the following variables had to be borne in mind.

1) the size of the visual arrays under consideration
2) the meaningfulness and redundancy of visual stimuli
3) the number of stimuli in the array
4) the location of the stimuli in the array
5) the age of the subjects.

Although the ability of subjects to voluntarily attend to and identify the experimental stimuli in the periphery could not definitely be ascertained, it seemed unlikely from the available evidence that there were no differences in the amount of information available to subjects of different ages. What did seem likely was that, with increasing age, whatever information was available from the periphery would be translated more efficiently into directions for further EMs. The only way to provide any definite answers was to proceed with the study and look to the results for the answers. If more appropriate first eye movements (FEMs) were made to true items where the relevant picture was present in the periphery than to non-binary false items where the mentioned picture was not present then it would seem information was being extracted from the periphery in a way that was "weakly constrained" by the linguistic task. If this was the way the visual search was organized, then one would also expect an increased number of inappropriate FEMs for the binary trials, where the picture mentioned fell on the periphery but at a location defined as inappropriate for search in terms of the task.

2.7. Abbreviations and Definitions of Terms Used in Eye Movement Studies. As certain terms and labels were used extensively throughout the following pages, the abbreviations given to some, and explanations of the terms of reference of others, have been listed below.

Abbreviations

EM(s) Eye movement(s)

No. EM(s) Number of eye movement(s)

RT(s) Reaction time(s) or otherwise referred to as the judgement or verification time. RT extended from the onset of lights and hence the visual array to the moment when the subject pressed the button indicating his judgement of the truth or falsity of the sentence.

FFP	First fixated picture - the first picture to be seen after the onset of the lights.
SP(s)	Specified pictures - whichever pictures are mentioned in the sentence to be verified.
SPL(s)	Specified picture location - whichever picture location has been mentioned or indicated as relevant in the sentence to be verified.
FEM	First eye movement
AFEM(s)	Appropriate first eye movement(s) - as defined by the sentence to be verified in conjunction with the particular visual array seen.
IFEM(s)	Inappropriate first eye movement(s)
E	Experimenter
S(s)	Subject(s)
EMP(s)	Eye movement pattern(s)
ES	Efficient search pattern
SES	Semi-efficient search pattern
NES1	Non-efficient search pattern Number 1
NES2	Non-efficient search pattern Number 2
CJ	Correct judgement of appropriacy or truth value of sentence.
ICJ	Incorrect judgement of the truth value of the sentence
TV	Truth value of sentence to be judged.

CP Central processing description of sentence/picture verification processing.

R & S Recognition and selection description of sentence/picture verification processing.

Clarifications

Subject When referring to experimental subjects the word subject or abbreviation S was used. In accordance with convention, the S has been mainly referred to as "he" throughout this thesis, so as to at least maintain a semantic feature of(+animate). The feature(+male)is absent from the experimental lexicon being used.

Subject When being used in a linguistic sense, the full designation of either logical (LS) or grammatical subject (GS) was used.

Object When referring to 'things' the word object alone was used; when being used in a linguistic sense the full designation of either logical (LO) or gramatical object (GO) was used.

Logical Subject (LS) This designation was sometimes used interchangeably with 'agent' or 'actor'.

Logical Object (LO) This designation was used interchangeably with patient or the acted-upon element.

Correct An appropriate judgement whether it was true or false was called correct, the word right being reserved for true judgements.

Incorrect An inappropriate judgement "whether it was true or false" was called incorrect, the word wrong being reserved for false judgements.

Ages Throughout the text the ages of subjects will be given in the form x;y, i.e., 4;5 years. This is meant to indicate an age of x years and y months or, for example, four years and five months. When the number of months is expressed as a decimal fraction of a year the age will be given as x.y, i.e., 4.5 years or four and a half years.

CHAPTER 3

Development of the Ability to Make an Efficient Visual Search in a Sentence-Picture Verification Task Requiring Vertical Eye Movements

3.1. Introduction: In order to examine some of the factors influencing the visual search behaviour of subjects of various ages, a task was devised which required subjects to make a visual search in order to ascertain the truth value of a sentence, as described in Chapter 2.1. Several kinds of sentences were considered as candidates for the first test sentence paradigm. The paradigm had to fulfil two requirements; firstly that the subject would validly need to make gross EM's as part of his search; and secondly that even the youngest subjects would comprehend the particular sentences to be verified.

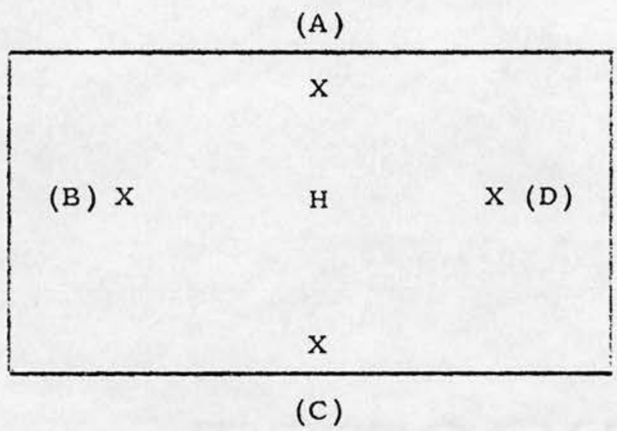
3.2. Sentences: Sentences describing certain kinds of spatial relationships between two objects met the first requirement. One EM study which used sentences describing relationships of "in front of" and "behind" in a two-dimensional space, was carried out but the second requirement did not hold for all of the younger subjects. A report of this study has been deferred until Chapter 6, so that development differences in task performance could first be established for a task where all subjects fully comprehended the sentences to be verified.

The study to be reported used sentences which described the spatial relationship between two objects in terms of the spatial prepositions, "at the top of" and "at the bottom of".

A pilot test with 18 nursery school children (mean age 4;8 years, range 4;0 - 4;11 years) established that all the children were able to correctly carry out instructions requiring them to place a picture "at the top of" or "at the bottom of" a board placed in front of the child in the fronto-parallel plane. The board, which measured $11\frac{1}{2}$"x $11\frac{1}{2}$" had five hooks equally spaced along both the vertical and the horizontal axes, which divided the board into quadrants. The children were not as successful when instructed to place a picture "above" or "below" another picture placed on the central hook. Since "at the top of" and "at the bottom of" filled both task requirements, experimental trials were designed using these sentences to be verified against arrays which varied in specified ways. The sentences used took the form "X is at the top of/at the bottom of the box" where X was the name of the object represented by the picture specified in the sentence. The use of these sentences also allowed further investigation of the claims made about preferences for upward and downward EMs touched upon in Chapter 2, 5.2.

3.3. Arrays: The arrays against which the sentences were to be judged were composed of up to four pictures which could each be placed in four possible locations with the qualification that no more than one picture could be present at any one location on a given trial. The top and bottom locations, labelled A and B respectively, lay at the intersection of the vertical axis throughout the H location with the upper and lower boundaries of the back face of the box. The other two locations lay along the horizontal axis through H location and were both as equidistant from H as A and B locations. The left-hand location as seen by the subject was labelled C and the right hand location labelled D. Diagram 3.1 illustrates the arrangement of the four possible locations for the pictures used in the various arrays.

Diagram 3.1. Back face of box as viewed by Ss



The kinds of pictures used in the arrays and the method of presentation have been described in Chapter 2.1. For any one array the size of the pictures used was equated as nearly as possible. The distance between the outer boundaries of A and C, B and D subtended an angle of $28^{\circ}28'$ at the Ss eye while the distances between the inner boundaries of A and C, B and D subtended an average angle of $23^{\circ}14'$. The distances between H and the inner and outer boundaries of any picture subtended angles half the size of those mentioned above. The distances between the inner and outer boundaries of A and B, B and C, C and D and D and A subtended an average of $17^{\circ}30'$ and $22^{\circ}30'$.

3.4. <u>Experimental Variables and the Design of Experimental Conditions</u>: The conditions were designed so as to investigate the effect of several variables on task performance. The first variable was the direction of the EM required in order to find the information to judge the sentence. The second variable was the truth value of the sentence, which involved three kinds of experimental trials. One trial required a true (T) judgement, one required a false (F+) judgement because an unspecified picture was in the specified location, and one trial required a false (F-) judgement because no picture was in the specified location. Thus six experimental trials were used to investigate these two variables. Four practice trials were also given to each subject, with each kind of sentence requiring one true and one false judgement. The 'top' sentence received the F+ trial and the 'bottom' trial received the F- trial. The third variable was the effect of irrelevant information on the ability of subjects of different ages to carry out efficient visual searches. In order to investigate this variable the different groups of subjects viewed the six experimental trials under different conditions. The first condition labelled the <u>One-Picture (1P) Condition</u> provided the simplest array against which to judge the test sentence since a maximum of 1 picture composed the array. Thus the sentence was either true because the picture specified was in the specified location or false because another picture was in the specified location or false because no picture was in the specified location. In no case was there another picture present in any other location on the visual field. This condition was included so as to provide a comparison against which to judge the effect of the presence of an irrelevant picture.

The second condition was designated as the Two Picture (2-P) Condition since there was a maximum of two pictures present in the visual array against which the sentence was to be judged. This was because an irrelevant picture was present in the array. This picture was placed at B location if A was specified in the sentence or it was placed at A location if B was specified in the sentence. In this way the retinal images of the relevant and irrelevant pictures fell an equal distance from the initial fixation point but in opposite directions along the vertical axis. For the true judgements the arrays consisted of the specified picture in the specified location as well as another picture in the alternate location. For F+ judgements A and B locations were both occupied by unspecified pictures, while for F- judgements no picture was present in the specified location, but another picture occupied the alternate location.

In a third condition designated as the Binary Two Picture (B.2-P) Condition the arrays were structured in the same way as for the 2-P condition except that for the false trials, the picture occupying the unspecified alternate location was the picture mentioned in the sentence. Thus for the F+ trials the sentence could be said to be false either because an unspecified object was in the location mentioned or else because the picture mentioned was in the unspecified location. Similarly in the F- trials the sentence could be judged false because there was nothing in the specified location or because the specified object was in the unspecified location. The two false practice trials were also binary in nature. This condition was included so as to provide a check that the subjects realized that the location as well as the identity of the picture mentioned in the sentence needed to be verified against the array. The binary trials were tested separately from condition two so as to evaluate if different strategies even used for judging the two kinds of items. Binary items allowed the subject to make an efficient search regardless of which of the two locations was searched.

In the fourth and final condition labelled the Four Picture (4-P) Condition, the same basic arrangement was used as in the 2-P condition except that two more irrelevant pictures were always present in each array, being placed at C and D locations. As in the 2-P condition the irrelevant pictures varied from trial to trial.

A full description of the sentences and arrays used in conditions 1P, 2P, B2P and 4P is given in Appendix 3.1. Table 3.1 given below summarizes the structure of the arrays used in the four conditions. Pictures specified and unspecified by the sentence are labelled SP and UP respectively while specified and unspecified locations are labelled SL and UL respectively.

Table 3.1. Summary of Arrays used in Four Experimental Conditions.

Condition	Experimental Trials T	F+	F-
1P	SP in SL	UP in SL	No picture in SL
2P	SP in SL 1UP in 1UL	UP in SL 1UP in 1UL	No picture in SL 1UP in 1UL
B2P	SP in SL 1UP in 1UL	UP in SL 1SP in 1UL	No picture in SL 1 SP in 1UL
4P	SP in SL 3UP in 3UL	UP in SL 3UP in 3UL	No picture in SL 3UP in 3UL

3.5. Subjects: Subjects were selected and recruited as described in Chapter 2.2.

One group of 16 four year olds and one group of 8 older children took part in the study in Condition 1P. Another group of 16 four year olds and another group of 8 older children performed the task under Condition 2-P. Two further groups composed of 8 older and 8 younger children underwent Condition B-2P. Eight adults also performed the task under the 2P Condition as well as carrying out a binary F+ trial for both a "top" and a "bottom" sentence.

Four groups of eight subjects roughly described as younger children, older children, teenagers and adults performed the experimental trials under condition 4P.

The mean ages and range of ages of the subjects in each group have been summarized in Table 3.2.

The six trials were divided into two groups of three so that each group contained one true, one F+ and one F-

Table 3.2.

Mean Ages and Range of Ages of Subject Groups. (Given in Years and Months).

Condition	Group	No. in Group	Mean Age Years and Months	Range of Ages
1P	G1	16	4;6	3;11 - 4;9
	G2	8	7;7	6;3 - 8;11
2P	G1	16	4;5	3;10 - 4;10
	G2	8	8;4	6;1 - 10;5
	G3	8	26.0	21.0 - 35.0
B-2P	G1	8	4;5	3;10 - 4;9
	G2	8	8;2	6;1 - 10;9
	G3 (F+trials only)	8	26.0	21.0 - 35.0
4P	G1	8	4;4	3;10 - 4;9
	G2	8	8;2	6;6 - 9;8
	G3	8	13;4	12;0 - 15;5
	G4	8	25.0	22.0 - 31.0

trial but one group labelled A required judgements to be made about two 'bottom' sentences and one 'top' sentence, while the other group labelled B required judgements to be made about two 'top' sentences and one 'bottom' sentence. Half the subjects in each age group received group A trials first while the other half received group B first. The order of trials within groups A and B were varied in a balanced way across the subjects in each group.

3.6. Protocol. The only addition to the procedures and instructions as described in Chapter 2.3, required the subject to describe to the experimenter the position of a picture when placed at A or B locations before the presentation of any verification trials. This was to ensure that the child understood which area was referred to by "the top of" or "the bottom of" the box.

3.7. Scoring: The video-records of each subject's EM s were scored in the manner described in Chapter 2.4, so as to provide data about each subject's RTs, number of EMs, the FEM and pattern of EMs for each trial.

3.8. Analyses: The data was analysed so as to discover if any of the experimental variables (age, specified picture location, truth value and number of irrelevant pictures in the array) affected the performance of the Ss in terms of the four kinds of measures. Firstly, the data was analysed so that for each array condition (IP, 2P, B2P and 4P) comparisons were made between each age group, between trials requiring different truth judgements. Three-way Analyses of Variances with repeated measures on two factors were used to examine performance in terms of RTs and No. EMs. A Three-way Partitioning of Chi-square (Winer, 1970, p.629), was used to examine performance under each condition in terms of the AFEM measure. Winer refers to Sutcliffe (1957) for a fuller treatment of the rationale underlying the use of this analysis. A Four-way Partioning of Chi-square was used to examine performance in terms of EM search patterns, where the kind of pattern used as well as factors of age, specified picture location and truth value, was of interest.

Individual comparisons, following upon significant overall comparisons, were made using the Tukey test (Guilford, J., 1965, p.276) for the RT and No. EM measures, and the Wilcoxin Matched Pairs test, the Mann-Whitney U test and the Kolmogorov-Smirnov Two Sample test (Siegal,S., 1956, p.75 and p.116) when appropriate for the AFEM and EM pattern measures.

In order to compare groups of different size in the analyses of variance the Group 1 Ss were divided into two equal sized groups of eight Ss each, with an equal number of males and females in each group as well as an equal number of Ss signalling the judgement with their left and right hands. Since the results for both groups were comparable for all comparisons the mean group score of the two groups has been given in the tables of results. Levels of significance appropriate for a one-tailed test were used when comparing age groups and the effect of irrelevant pictures, but levels of significance approp- riate for a two-tailed test were used when comparing the specified picture locations and truth values.

As well as comparing the performance of Ss from different age groups under one condition, comparisons were also made for each measure between groups of Ss drawn from the same age range but performing the task under different conditions. For the groups drawn from the pre- school age range and those drawn from the six-to-ten years age range, each measure was compared across the four conditions. For the RT and No.EM measures a One-way Analysis of Variance was used to compare the mean scores obtained by each group of Ss for each condition. For the AFEM and EM Patterns measures the Kruskal-Wallis One-way Analysis of Variance by Ranks (Siegal, S., p.184) was used to compare the performance of Ss of the same age range under different conditions. For adult Ss the AFEM and EM search pattern measures were compared between the 1P, 2P and 4P conditions with the performance of adults on the 1P condition being taken as at least equivalent to the nearly optimal performance of the Group 2 Ss on that condition. However the RT and No. EM measures of adults were only compared for the 2P and 4P conditions by means of a Student's T-test.

Where the same statistical tests have been employed in the analysis of data from other experiments, they have come from the same sources as referenced in this section.

3.9. <u>Results</u>. Firstly the effect of the experimental variables of age, truth value (TV) and specified picture location (SPL) on the Ss performance have been discussed for each experimental condition. Overall differences which are interesting for their significance or lack of it, have been summarized for each performance measure in a table of results for that condition. Significance levels for the overall differences have been given in the table of results and the significance levels for individual differences will be given in the text. It should be noted that where the analyses showed that the F value fell below a value of one, as it was not given in the computer print-out, it has been omitted from the tables. This has been indicated by a '-' sign. After the results for each condition have been presented, the results for comparisons across conditions have been presented. The results for the teenage Ss were not compared across conditions as they only took part in the 4P Condition.

3.9.1. <u>One Picture (1P) Condition</u>. Table 3.3 should be referred to for the results of the 1P Condition. When only one or no picture was present in the visual field nearly all Ss of both age groups were able to direct their FEMs appropriately to the picture location specified on any particular trial. No significant differences were found for any of the experimental factors.

Not only were the FEMs appropriate when no irrelevant pictures were present but efficient EM patterns were predominantly made with significantly ($T=0$, $N=19$, $p=.001$ for the smallest difference) more Ss making ES patterns than SES, NES1 and NES2 patterns, and significantly ($T=22.5$, $N=17$, $p=.001$ for the smallest difference) fewer Ss making NES2 patterns than any other kind. There was no difference between the groups in terms of the number of efficient search patterns made. There was however a significant interaction between the kind of pattern and the SPL, with significantly ($T=26$, $N=18$, $p=.01$) more ES patterns being made on 'bottom' trials than on 'top' trials while there were no differences between the SPL in terms of the other three kinds of search patterns. It would seem that it was easier to inhibit search to other locations having made a downward EM than when an upward EM was made. Two factors which may have some bearing on this finding will be briefly mentioned. Firstly the presence of the lights

TABLE 3.3.

1-P Condition Mean Scores for Certain Comparisons with F or Chi-Square Values and Levels of Significance

Measure	Comparison	F or χ^2 Value	df	Level of Sig.		Mean Scores			
Mean No Ss Making AFEMs	Age (G1 v G2)	0.10	2	NS		7.58 v 8.00			
	TV (T v F+ v F-)	0.57	2	NS		7.83 v 7.50 v 7.83			
	SPL(T v B)	0.01	1	NS		7.67 v 7.78			
						ES	SES	NES1	NES2
Mean No. Ss making EM Patterns	Patterns	160.90	3	.001		5.61	1.05	1.11	0.22
	Patterns x TV	43.89	6	.001	T	7.16	0.33	0.50	0.0
					F+	6.67	0.50	0.67	0.17
					F-	3.00	2.33	2.17	0.50
	Patterns x SPL	11.39	3	.01	T	4.67	1.56	1.44	0.33
					B	6.56	0.56	0.78	0.11
Mean No. EMs	Groups	4.20	2/21	.05		3.04	2.06		
	TV	33.08	2/42	.001		1.85	2.25	4.04	
	SPL	2.55	1/21	NS		2.89	2.54		
	Group x	5.34	4/42	.01	T	2.19	1.19		
					F+	2.44	1.88		
					F-	4.50	3.13		
Mean RTs (secs)	Groups	5.89	2/21	.01		4.06	2.52		
	TV	7.08	2/42	.01		2.64	3.64	4.33	
	SPL	-	1/21	NS		4.08	3.71		

at the bottom but not the top of the box, may have held the Ss gaze to the bottom of the box once he had looked down or attracted his gaze from the top when he appropriately looked up. Alternatively, when the gaze is directed downwards the upper lid lowers, making less of the upper half of the visual field visible while the reverse is not true of the lower lid when the gaze is directed upwards.

The number of Ss making the different kinds of searches varied significantly with the truth value of the sentence being verified, or more specifically with the presence or absence in the array of a picture against which to judge the sentence. Thus there was little difference between the search patterns employed by Ss on the T and F+ trials but significantly (T=0,0, N=23,19, p=.01) fewer ES patterns made on F- trials than on T and F+ trials and significantly (T=0,3, N=21,22, p=.01) fewer SES patterns made on F- than on T or F+ trials. On the other hand significantly more NES1 patterns were made on F- than on T or F+ trials (T=28,25 N=19,17, p=.01, .02) and more NES2 patterns were made on F- than T trials (T=20, N=14, p=.05). There was no difference in the number of NES2 patterns made for any truth value. When no picture was present in the SPL nor anywhere else in the visual field, Ss found it very difficult to inhibit additional EMs after inspecting the relevant location, although capable of doing this on T and F+ trials.

The search pattern findings fit neatly with the factors found to have a significant effect on the total No. EMs made by the S while verifying the sentence. The older group of

Ss made significantly (p=.05) fewer EMs than the younger group. Truth value also significantly affected the number of EMs with significantly (p=.01) more EMs being made on F- trials than on T or F+ trials. Moreover age interacted significantly with truth value, since there was a significantly greater (p=.02) difference between F- and F+ trials for Group 1 than there was for Group 2, with Group 1 Ss making more EMs on F- trials than on F+ trials.

Reaction times were analysed in a similar manner to the EM data with age emerging as a significant (p=.01) factor, with the older group taking less time as well as fewer EMs to make a judgement than the younger group. Differences in the time taken to judge T and F- trials were significantly (p=0.05) different although differences between F+ and F- trials RTS were not. However the order of difficulty corresponded to the order expected from the finding that more EMs were made on F- trials than T or F+ trials. Similarly differences between the time taken to make a judgement about 'top' and 'bottom' sentences were not significantly different but were ordered in a way that fitted with the finding that more ES patterns were made on 'bottom' than on 'top' trials.

The basic points to bear in mind when considering findings about the performance of the Ss when irrelevant pictures are introduced into the array arethat even the four to five year old child was able to appropriately direct his EMs and to carry out more or less efficient searches when there were no pictures in locations other than the one specified by the sentence. This was the case even though the younger Ss took longer and made more EMs overall than the older Ss.

3.9.2. Two Picture (2P) Condition. Table 3.4 should be referred to for the scores and results for this condition. The introduction of one irrelevant picture into the array did not differentially affect the number of Ss in the different age groups making AFEMs to any significant extent, although there was a tendency for more adults than pre-school Ss to make AFEMs. In contrast to the 1P Condition the truth value of the trials did affect the number of Ss making AFEMs, with significantly more AFEMs being made on T ($T=7.5$, $2=17.8$, $N=27$, $p=.001$) and F+ ($T=28.5$, $N=25$, $p=.01$) trials than on F- trials. Thus, so long as there was a picture in the SPL, whether or not it was the one specified in the sentence, the AFEMs on T and F+ trials were not differentially affected by the irrelevant picture. However the absence of a picture in the specified location resulted in more Ss looking to the only picture in the visual field rather than to the SPL.

As well as affecting the Ss FEMs, the addition of an irrelevant picture seemed to have a distracting effect on the way subsequent EMs were organized as can be seen from the EM pattern results. Instead of Groups 1 and 2 making mainly ES patterns, as in the IP Condition, significantly ($Z=2.09$, $T=26$, $T=50$, $N=29,25,24$, $p=.02,.01,.01$) more Ss made NES1 patterns than ES, SES or NES2 patterns respectively and significantly ($T=25$, $N=18$, $p=.01$) more Ss made NES2 patterns than SES patterns. A significant Pattern by Groups interaction indicated that significantly

TABLE 3.4.

2-P Condition Mean Scores for Certain Comparisons with F or Chi-Square Values and Levels of Significance.

Measure	Comparison	F or χ^2 Value	df	Level of Sig.	Mean Scores				
Mean No. Ss making AFEMs	Groups (G1,G2,G3)	3.58	3	NS	4.15 v 5.0 v 6.1				
	SPL(Top/ Bottom)	0.42	1	NS	5.1 v 4.5				
	TV (T,F+,F-)	21.90	2	.001	7.0 v 5.6 v 2.0				
Mean No. Ss making Search Patterns						ES	SES	NES1	NES2
	Patterns	24.8	3	.001		1.75 v	3.17 v	1.21 v	1.87
	Groups x Patterns	39.7	9	.001	G1	0.88	3.93	1.00	2.50
					G2	1.33	2.67	1.67	2.33
					G3	4.00	2.67	1.17	0.17
	TV x Patterns	76.1	6	.001	T	3.75	2.62	1.25	0.37
					F+	0.75	4.25	2.12	0.87
					F-	0.75	2.62	0.25	4.37
	Groups x Patterns x TV	31.75	18	.05	T				
					G1	2.25	3.25	1.25	0.75
					G2	3.50	2.50	2.00	0.00
					G3	7.00	0.50	0.50	0.00
					F+				
					G1	0.25	5.00	1.75	1.00
					G2	0.50	3.50	2.50	1.50
					G3	2.00	3.50	2.50	0.00
					F-				
					G1	0.00	2.75	0.00	5.25
					G2	0.00	2.00	0.50	5.50
					G3	3.00	4.00	0.50	0.50
Mean No. EMs	Groups	8.31	3/28	.01	3.16 v 2.42 v 1.81				
	SPL	-	1/28	NS	2.46 v 2.29				
	TV	10.42	2/42	.01	1.91 v 3.00 v 2.44				
Mean RTs (in secs)	Groups	14.90	3/28	.001	4.31 v 2.00 v 1.40				
	SPL	-	1/28	NS	3.12 v 2.92				
	TV	-	2/56	NS	2.79 v 3.15 v 3.12				

(K_D=5,5, N=8, p=.05) more adult Ss (Group 3) made ES patterns than did Group 1 or Group 2 Ss, and significantly (K_D=6,6, N=8, p=.05) more Group 1 and 2 Ss made NES2 patterns than did Group 3 Ss. An interesting finding emerged inasmuch as it was only adult Ss, who on 2 occasions did not make detectable EMs away from the H position on F- trials, but detected the absence of a picture from the periphery and made a judgement on that basis. A significant Pattern by Truth Value interaction indicated that significantly (T=5.5, 0, N=13, p=.01) more Ss made ES patterns on T trials than on F+ or F- trials, and significantly (T=0,6.5, N=19,21, p=.01) more Ss made NES2 patterns on F- trials than on T or F+ trials. Also, significantly (T=17,47.5, N=17,21, p=.01,.02) more Ss made NES1 patterns on F+ than on T or F- trials. A significant Group by Truth by Pattern interaction reflected the fact that only adult Ss made ES patterns on F- trials whereas most of Group 1 and 2 Ss made NES2 patterns. On F+ trials Group 3 Ss also tended to make more efficient searches than did Group 1 and 2 Ss but on T trials more Ss from the younger groups made ES and SES patterns than they had done on the F- trials.

When the No.EM measure was considered, age and TV proved to be significant factors. Significant (p=.01) differences were found between the No.EMs made by Groups 1 and 3 but not between those made by Groups 1 and 2 nor between Groups 2 and 4. However the groups were ordered in such a way that the older the group the fewer EMs were made. Differences between the No.EMs made on trials with

T and F+ values were significantly (p=.01) different but differences between T and F- trials and F- and F+ trials were not significant. It would seem that on T and F- trials one picture location was fixated either because the picture specified was there or else because it was the only picture present, whereas on F+ trials more EMs were made because two pictures were available, neither of which had been specified in the sentence.

The same factors of age and TV affected the RT measure, with significant (p=.01) differences occurring between Groups 1 and 2 as well as 1 and 3 but not between Groups 2 and 4. Thus adults were not significantly faster at judging the sentences than the Group 2 Ss, when one irrelevant picture was present. True trials took significantly (p=.05) less time to judge than F+ or F- trials.

Thus when one irrelevant picture was present adults were superior in performance to Group 1 Ss in terms of RTs, No.EMs and better than Group 2 Ss only in terms of the number of ES patterns made.

The factor of SPL had no significant effect on any measure.

3.9.3. Binary Two Picture (B2P) Condition. Table 3.5 should be referred to for the scores and results for this condition.

In terms of the ability of the Ss to make AFEMs on B2P trials only TV had a significant effect although age was nearly but not quite significant at the p=.05 level with Group 2 Ss making more AFEMs than Group 1 Ss. With respect to the effect of TV it is necessary to note that

TABLE 3.5.

Binary 2P Condition Mean Scores for Certain Comparisons with For Chi-Square Values and Levels of Significance

Measure	Comparison	F or χ^2 Value	df	Level of Sig.		Mean Scores			
Mean No. Ss making AFEMs	Age (G1 & G2)	3.19	1	(.05)*		3.33	v 5.50		
	SPL(T/B)	2.83	1	NS		5.33	v 3.50		
	Truth Value(TV)	9.77	2	.01		6.00	v 5.50	v 1.75	
Mean No. Ss making Search Patterns						ES	SES	NES1	NES2
	Patterns	37.91	3	.001		0.83	v 3.91	v 0.92	v 2.33
	Patterns x TV	36.08	6	.001	T	2.0	4.5	1.5	0.0
					F+	0.25	4.5	1.2	2.0
					F-	0.25	2.7	0.0	5.0
Mean No. EMs	Groups	-	1/14	NS		2.77	v 2.54		
	SPL	1.41	1/14	NS		2.54	v 2.77		
	TV	4.35	2/28	.05		2.28	v 3.09	v 3.59	
Mean RT (in secs)	Groups	6.99	1/14	.05		3.53	v 2.18		
	SPL	-	1/14	NS		2.90	v 2.81		
	TV	1.32	2/28	NS		2.56	v 3.02	v 2.99	
<u>ADULTS</u> Mean No. Ss making AFEMs						T	F+	F-	BF+
	TV	1.31	3	NS		8.0	v 5.5	v 6.5	v 5.5
	SPL	0.49	1	NS		5.75	v 7.0		
Mean No Ss making EM patterns						ES	SES	NES1	NES2
	Patterns	43.25	3	.001		4.37	v 2.62	v 0.87	v 0.12
	Patterns x TV	26.75	9	.01	T	7.0	0.5	0.5	0.0
					F+	2.0	3.5	2.5	0.0
					F-	3.0	4.0	0.5	0.5
					BF+	5.5	2.5	0.0	0.0
Mean No. EMs						T	F+	F-	BF+
	TV	5.79	3/21	.05		1.37	v 2.37	v 2.19	v 1.31
Mean No. RTs (secs)	TV	14.03	3/21	.01		1.06	v 1.76	v 1.60	v 1.21

*Nearly significant at .05 level

there was no difference between the number of Ss making AFEMs on T and F+ trials although significantly (T=7,6, N=16, p=.01) more Ss made AFEMs on T and F+ trials than on F- trials. Thus, Ss did not look first to the specified picture rather than the specified location on F+ trials having first located the picture by means of peripheral vision. It was only on F- trials that Ss looked first to the specified picture in the inappropriate location as it was the only picture present in the array.

The number of Ss making each kind of search pattern differed significantly over all trials and also differed with respect to trials with certain truth values. Significantly (T=0,1,0, N=11,12,14, p=.01) more Ss made SES patterns than NES2, NES1 and ES patterns and significantly (T=0,0, N=10, p=.01) more Ss made NES2 patterns than ES or NES1 patterns which did not differ significantly themselves. Thus Ss tended to look either more to the inappropriate location or more to the appropriate location. The Truth Value by Patterns Interaction was significant with no differences occurring bdtween the number of Ss making SES and NES1 patterns on T, F+ and F- trials but significantly (T=10,0, N=12,14, p=.05, .01) more Ss making NES2 patterns on F- trials than on F+ and T trials and significantly (T=0,0 N=6 p=.05) more Ss making ES patterns on T trials than on F+ and F- trials. It is interesting to note that on 10 out of 32 F- trials, Group 1 Ss looked only to the mentioned picture in the unspecified location and then made a decision without ever referring to the specified location. The presence of the picture in an inappropriate location was sufficient for a decision when no other picture was present.

When it came to the No.EMs made while verifying sentences in a binary situation only TV was shown to have a significant effect. Significantly (p=.05) more Ems were made on F+ trials than on either T or F- trials which did not differ significantly from each other. When the EM pattern results are taken into account these findings can be described more fully. On the T trials more Ss looked appropriately and seemed able to make a judgement after referring only to the mentioned picture or else looked to the alternate location after the FEM but subsequently referred back to the specified picture in the specified location. On F- trials Ss tended not to make AFEMs but to look to the alternate location and on finding the specified picture tended to stop searching although a few Ss referred to the empty specified location. On F+ trials however when there was a picture in the designated picture position Ss would look appropriately but on failing to find the specified picture would continue to search the alternate location as well as referring back to the specified location. Thus more Ss referred to both pictures on F+ trials than on T or F- trials, thus making more EMs on this sort of trial.

When the RT measures were considered only the age factor had a significant effect on the speed of decision-making, with SPL and TV factors not being significant although the order of the mean RTs for the various truth values corresponded to that found under the 2P Condition

(T, F+ and F-), which fits with the fact that fewer EMs were made on true than false trials. Thus it would seem that those fixations which were made on T trials were of greater duration than the greater number of EMs which were made on F+ trials but within only a slightly greater time. Again, as in the 2P Condition the difference between the F+ and F- trials was not significant.

The adult group whose performance under the 2P Condition has already been discussed, also performed two binary F+ trials at the end of the six 2P Condition trials. When their performance on these trials was compared with that observed on the other trials, no significant differences were found between the number of Ss making AFEMs on binary F+ trials and any other truth value trials. And although a significant Pattern by TV Interaction was found to affect the number of Ss making EM patterns, no difference was found between T and binary F+ trials. In fact slightly more Ss made ES patterns on binary F+ trials than on F+ trials, so there was no evidence that adult Ss were directing their FEMs according to peripheral information identifying the mentioned pictures rather than in terms of the specified location. Even if the Ss were able to identify the mentioned picture while fixating the H position, they did not use that information to guide their FEM.

When it came to RTs and the No.EMs made on BF+ trials, the judgements were made more quickly and with fewer EMs than both F+ and F- trials and made nearly as efficiently as T trials. Because adults were not distracted by the irrelevant picture, even though it was the one specified in the sentence, they were able to judge the sentences false just as quickly as true.

3.9.4. Four Picture (4P) Condition. The results from this condition where three irrelevant pictures were included in the array, provide an interesting contrast with those from the 1P Condition. Instead of the children from Groups 1 and 2 performing at a nearly optimal level with respect to the AFEM measure, the subjects from these two age ranges were worse at directing their FEMs appropriately. Only Group 3 (Teens) and Group 4 (Adults) Ss were able to ignore the irrelevant pictures for at least the FEM. Table 3.6. provides a summary of the findings for all measures. As can be seen from the table both the age of the S and the truth value of the trial affected the ability of Ss to make AFEMs, with significantly (K_D=6 in each case, N=8, p=.05) more Group 3 and 4 Ss making AFEMs than Ss from Groups 1 and 2, and significantly (T=0,0, N=18,17, p=.01) fewer AFEMs being made on F- trials than on T or F+ trials which did not differ from each other. The Groups by TV Interaction was significant, with Groups 1 and 2 being significantly (T=0, N=8, p=.05 for the smallest difference) poorer than Groups 3 and 4 at directing their FEMs to the appropriate but vacant location on F- trials. The SPL factor did not affect the AFEM measure.

With regard to the EM search pattern measure, a significant difference was found between the number of Ss making each of the kinds of EM patterns, with significantly

TABLE 3.6.

4-P Condition Mean Scores for Certain Comparisons with F or Chi-Square Values and Levels of Significance

Measure	Comparison	F or χ^2 Value	df	Level of Sig.		Mean Score			
Mean No SS making AFEMs	Age (G1, G2,G3,G4)	7.97	3	.05		4.33 v 5.67 v 7.83 v 7.66			
	SPL(Top/ Bottom)	0.06	1	NS		6.50 v 6.25			
	TV(T,F+, F-)	6.63	2	.05		7.37 v 7.25 v 4.50			
	Age X TV	4.40	6	NS		G1	G2	G3	G4
					T	5.5	8.0	8.0	8.0
					F+	5.5	7.5	8.0	8.0
					F-	2.0	1.5	7.5	7.0
Mean No SS making each EM Pattern	Patterns (ES,SES, NES1, NES2)	100.70	3	.001		ES	SES	NES1	NES2
						3.83 v 0.95 v 0.25 v 2.92			
	Patterns x Age	164.00	9	.001	G1	0.66	1.17	0.67	5.50
					G2	1.67	1.33	0.17	4.83
					G3	5.67	1.00	0.17	1.17
					G4	7.50	0.33	0.00	0.17
	Patterns x TV	42.50	6	.001	T	5.50	1.12	0.50	0.87
					F+	3.37	0.87	0.25	3.50
					F-	2.75	0.87	0.00	4.37
Mean No EMs	Age	17.59	3/28	.001		4.14 v 2.98 v 1.77 c 1.20			
	TV	22.32	5/56	.001		1.76 v 2.84 v 2.91			
	SPL	-	1/28	NS		2.45 v 2.56			
	Age x TV	3.10	6/56	.05		G1	G2	G3	G4
					T	3.06	1.75	1.25	1.00
					F+	4.69	3.75	1.75	1.17
					F-	4.69	3.44	2.31	1.19
Mean RTs	Age	4.98	3/28	.01		3.77	2.22	1.92	0.98
	TV	-	2/56	NS		2.50	2.10	2.06	
	SPL	1.59	1/28	NS		2.50	1.94		

(T=14.5,34, N=25,26, p=.01) more Ss making ES and NES2 patterns than SES or NES1 patterns. No differences were found between ES and NES2 patterns nor between SES and NES1 patterns. Moreover the effect of the kind of pattern interacted with that of TV and that of age. The Pattern by TV Interaction meant that significantly (T=0,0 N=13,18, p=.01) more Ss made ES patterns on T trials than on F+ and F- trials and significantly (T=0, N=7, p=.02) more Ss made ES patterns on F+ trials than on F- trials. The converse situation showed significantly (T=1, N=9, p=.01) more Ss making NES2 patterns on F- trials than on F+ trials and significantly (T=0, N=15, p=.01) more NES2 patterns on F+ trials than on T trials. There were no differences between the number of Ss making either SES or NES1 patterns on T, F+ or F- trials.

The Patterns by Group Interaction meant that Group 3 and 4 Ss made significantly (T=1.5, N=8, p=.02 for the smallest difference) more ES patterns than Group 1 and 2 Ss and significantly (T=0, N=7, p=.01 for the smallest difference) fewer NES2 patterns than Group 1 and 2 Ss. No differences between Groups were observed for SES and NES1 patterns. As far as ignoring irrelevant pictures went, the dividing line was between Group 2 and Group 3 Ss. Only the two older groups were able to inhibit unnecessary EMs on F+ and F- trials.

The factors significantly influencing the No.EMs made up till the time of judgement included Age, TV and an Age by TV Interaction, thus confirming the findings of the EM pattern data. Significant (p=.05) differences in terms of the No.EMs made, were found between Groups 1 and 2, and between Groups 2 and 3 but not between Groups 3 and 4. Thus the No.EMs measure was a more sensitive measure of age differences between Groups 1 and 2 than the AFEM or Pattern measures. The older the S, the fewer EMs were made before giving a decision. Significant (p=.001) differences were also found between T and F+ trials and T and F- trials but not between F+ and F- trials, with fewer EMs being made on T trials. The significant interaction of age and truth value reflected many significant differences between trials with different truth values when compared between the age groups. Differences between T and F+ trials were significantly (p=.001) greater for Group 1 than for Groups 3 or 4, with more EMs being made on F+ trials than on T trials by Group 1. Differences between T and F+ trials were also significantly (p=.001) greater for Group 2 than for Groups 3 or 4. Differences between T and F- trials were significantly (p=.001) greater for Group 1 than for Groups 3 or 4, and significantly (p=.001) greater for Group 2 than Group 3 and for Group 3 than Group 4. In each case more EMs were made on F- trials than on T trials. Differences between F+ and F- trials were significantly (p.001) greater for Group 3 than for Groups 1, 2 or 4, with more EMs being made on F- trials than on F+ trials. It would seem then that the two younger Ss distinguished between T and any sort of F trial, but it was not until their teens that Ss were more able to handle F+ than F- trials and not until adulthood that they were able to deal efficiently with F- trials.

When the RT data was considered, the only factor found to have a significant effect was the age of the S, with Groups 3 and 4 taking significantly ($p=.05$) less time to verify a sentence than Group 2 Ss who in turn took significantly ($p=.05$) less time to verify a sentence than Group 1 Ss. Neither TV nor SPL proved to be significant. Thus it would seem that within each group Ss were able to carry out their searches within more or less the same span of time, regardless of whether the search was efficient or inefficient and whether significantly more EMs were made on some trials than on others.

One explanation might be that Ss were able to adjust the time parameters of the search and verification processes by either compressing or expanding the duration of their eye fixations according to difficulties found in generating a picture description to match against the sentence. Thus on true trials, although fewer EMs were made, the Ss took slightly longer to make a judgement than false trials when more EMs were made. In order to make some interpretation of this finding it is necessary to assume that Ss are searching for the mentioned picture in order to describe the array, and that fixations of short duration are made when none of the pictures can be so identified. This would mean that when the mentioned picture was located as on T trials fewer but longer EMs would be made whereas the absence of the specified picture on F trials would lead to many EMs of shorter duration. This would most likely apply to Ss in the two younger groups as the teenagers and adults were able to carry out more efficient searches regardless of the truth value of the sentence and and thus no differences in RTs would be expected in any case. Unfortunately this proposal cannot be put to a direct test with the EM measures available in this study. However the issue will be raised again in the discussion which follows an examination of the results of comparisons across conditions and additional indirect evidence brought to bear on the matter.

Whatever the explanation of the discrepancy between RT and other measures, it is obvious that RT data by itself does not reveal the wealth of information that is important for any complete understanding of the development of comprehension and verification processes.

3.9.5. Comparisons of Comparable Age Groups Across Conditions for Each Performance Measure.

AFEMs: Comparisons between the conditions for groups from the pre-school age range (G1s), for groups from the primary school age range (G2s) and for the adult (G3s) groups revealed significant overall differences between the number of Ss making AFEMs under the conditions, as can be seen from Table 3.7.

When individual comparisons were made within each of the age ranges the same pattern of results emerged for Groups 1 and 2, inasmuch as significant differences were found between the 1P Condition and each of the other conditions, but no differences were found between the 2P, B2P and 4P Conditions.

TABLE 3.7.

Mean Number of Ss Making AFEMs from Each Group Compared Between Conditions and the Levels of Significance of Any Differences between Groups within Each Age Range.

Conditions	Age Ranges		
	G1s	G2s	G3s
1P	7.56	8.0	8.0
2P	4.16	5.0	6.17
B2P	3.33	5.5	
4P	4.33	5.67	7.67
Kruskal-Wallis H Value	30.0 N=48	29.7 N=32	11.2 N=24
Level of Significance	P=.001	P=.001	P=.01

For G1s the differences between the 1P and each of the 2P, B2P and 4P Conditions were significant at the following levels: 1P and 2P - K_D=15, N=16, p=.01; 1P and B2P - U=14, N2=16, p=.001; 1P and 4P - U=14, N2=16, p=.001. For Group 2s the differences were significant at the following levels: 1P and 2P - K_D=7, N=8, p=.01; 1P and B2P - K_D=7, N=8, p=.01.

It seemed that one irrelevant picture was as distracting as three irrelevant pictures as far as making an AFEM was concerned, and that the picture in the irrelevant location was not significantly more distracting when it was the one mentioned in the sentence than when it was an unspecified picture.

For adult groups, when their performance on the 1P

Condition was assumed to be as good as that shown by the Group 2 S's on the same condition, a significant (K_D=6, N=8, p=.05) difference was found between the 1P and 2P conditions, but not between the 1P and 4P, nor between the 2P and 4P conditions. For adults one irrelevant picture was more distracting than three irrelevant pictures, at least during the initial stage of search, as though a certain number of irrelevant pictures were necessary before the S felt constrained to be efficient. It would seem that, unlike the younger Ss, the adults were indeed constrained by three irrelevant pictures, in this case the search strategy being planned and carried out regardless of the irrelevant pictures.

EM Search Patterns: For Ss in groups from each age range, significant differences in the frequency of occurrence of several kinds of EM patterns were found when compared between the four conditions for G1's and G2's and between three conditions for the adult groups as can be seen from Table 3.8. For the groups drawn from the pre-school age range there were significant (p=.001) differences between the conditions in terms of the mean number of Ss making ES, NES1 and NES2 patterns. As far as ES patterns were concerned, significant (p=.01 at least) differences were found between the 1P condition and each of the others, in the following way:- 1P and 2P - K_D=14, N=16, p=.01; 1P and B2P - U=21, N1/N2=8/16, p=.01; 1P and 4P -K_D=0, N1/N2=8/16, p=.001. No differences were found between the 2P, B2P and 4P conditions. For each significant difference more ES patterns

TABLE 3.8

Comparison of Mean Number of Ss Making Each Kind of Search Pattern Under Each Condition and Levels of Significance of Differences

Age Range of Groups	Conditions	EM Patterns			
		ES	SES	NES1	NES2
Group 1's	1P	5.25	1.00	1.50	0.25
	2P	0.83	3.67	1.00	2.50
	B2P	0.17	3.67	1.33	2.83
	4P	0.54	1.21	0.70	5.55
Kruskal Wallis H Values		28.9	12.6	--	38.9
Levels of Sig. (p =)		.001	0.1-0.2	NS	.001
Group 2's	1P	6.33	1.67	0.33	0.17
	2P	1.33	2.67	1.67	2.33
	B2P	1.50	4.17	0.50	1.83
	4P	1.67	1.33	0.17	4.83
Kruskal Wallis H Values		17.0	--	25.1	16.6
Levels of Sig. (p =)		.001	NS	.001	.001
Group 3's	1P	6.33	1.67	0.33	0.17
	2P	4.00	2.6	1.20	0.2
	4P	7.50	0.33	0.0	1.17
Kruskal Wallis H Values		11.8	6.96	5.7	--
Levels of Sig. (p =		.01	.05	.1-.05	NS

were made by the Ss performing under the 1P Condition.

For NES2 patterns, significant ($p=.01$ at least) differences were found between the 1P and 2P conditions, the 1P and 4P conditions and the B2P and 4P Conditions, with those Ss performing under conditions with more irrelevant pictures making more NES2 patterns in each case. These differences were associated with the following scores: 1P and 2P - $K_D=13$, $N=16$, $p=.01$; 1P and 4P - $U=0$, $N1/N2=8/16$, $p=.001$; B2P and 4P - $K_D = 6$, $N=8$, $p=.05$. Thus the more pictures were present in an array, the more likely Ss drawn from the pre-school age range were to look more often at the irrelevant picture locations than the relevant location.

No differences were found between conditions in the number of SES or NES1 patterns made by Group 1 Ss.

For Group 2 Ss significant differences were found between conditions for ES, NES1 and NES2 patterns, but again no significant differences were found between the number of Ss making SES patterns under any condition.

Significant ($K_D=8,6,8$, $N=8$, $p=.01$) differences were found in the number of Group 2 Ss making ES patterns when comparisons were made between the 1P Condition and each of the 2P, B2P and 4P conditions respectively, but no differences were found between the 2P, B2P and 4P Conditions. As with Group 1 Ss, the introduction of one irrelevant picture was as effective in reducing the number of Ss making ES patterns as the introduction of three irrelevant pictures.

The only significant ($p=.01$) differences found between Ss making NES1 patterns were between the 1P and 2BP conditions and the 2BP and 4P conditions with more NES1 patterns being made for the binary condition than for either the 1P or 4P Condition (K_D=6,6, N=8, p=.01). Thus when two pictures were present in the array, whether in a binary arrangement or not, Group 2 Ss tended to look more to the relevant location.

For NES2 patterns, significant differences were found between each of the following pairs of conditions: 1P & 2P; 1P & 4P; 1P & B2P; 2P & 4P, B2P & 4P (K_D=6,8,6,5,6 N=8, p=.01, .01, .01, .05 & .01 respectively). Thus the more irrelevant pictures were introduced into the array, the more likely it was that the irrelevant picture location(s) would be fixated more often than the relevant location.

For adult groups significant differences were found between conditions for ES and SES patterns, with significantly (K_D=6, N=8; p=.01) more Ss making ES patterns under the 4P than the 2P condition and significantly (K_D=6, N=8, p=.01) more Ss making SES patterns under the 2P than the 4P Condition. Again, it can be seen that the 4P Condition elicited more efficient search strategies from the adult Ss than did the 2P Condition, even though the adults used the next most efficient search strategy most often under the 2P Condition.

<u>RTs:</u> No significant differences were found between the mean times taken by Groups 1 and 2 Ss to verify the sentence under any of the conditions. Nor were there any significant differences between the RTs under the various conditions when only the verification times for T and F+ trials were considered. Significant differences (p=.001) were found between the adult groups, with longer being taken by the group

under the 2P condition than the group performing under the 4P condition.

TABLE 3.9.

Comparisons of Mean RT s for All Trials and T & F+ trials for Groups from Each Age Range Performing under the Various Conditions

Conditions		Group 1s	Group 2s	Group 3s
All Trials	1P 2P B2P 4P	4.062 4.337 3.530 3.766	2.520 1.999 2.222 2.230	 1.47 0.97
F or T Value		0.17(3/44)	.65(3/28)	4.69(14)
Level of Sig. (p =		NS		.001
T & F+ Trials	1P 2P B2P 4P	3.56 3.74 3.15 3.64	2.29 1.89 1.95 2.32	
F Value		.56(3/36)	.69(3/28)	
Level of Sig. (p =		NS	NS	

Number of EMs: When the groups within each age range were compared across conditions with respect to the mean No.EMs made for all trials, no differences were found between conditions for the Group 1 s and for the Group 2 s. Differences were found between conditions for the adult groups with more EMs being made by the group performing under the 2P Condition. When the same comparison was made for the Group 1 s and Group 2 s but comparing the mean number of EMs made on only T and F+ trials, significant differences were found between the conditions. For Group 1 Ss there were significant (p=.001) differences between each of the conditions with more EMs being made, the more pictures were in the array and more EMs being made on the 2P condition than on the B2P Condition. This would suggest that finding the mentioned picture helped the Group 1 Ss to inhibit further EMs.

For Group 2 Ss there were significant (p=.001) differences between the No.EMs made on the 1P condition and all other conditions but no significant differences between 2P, B2P or 4P conditions, although there was a tendency for more EMs to be made under the 4P Condition than the 2P Condition.

TABLE 3.10.

Comparison of the Mean No. EMs for All Trials and for T & F+ Trials for Groups from Each Age Range Performing under the Various Conditions.

Conditions		Group 1s	Group 2s	Group 3s
All Trials	1P	3.04	2.06	
	2P	3.16	2.41	1.96
	B2P	2.77	2.54	
	4P	4.14	2.97	1.19
F or T Value		3.11(3/44)	1.73(3/28)	T=4.8(14)
Level of Sig. (p =		NS	NS	.001
T & F+ Trials	1P	2.30	1.45	
	2P	3.31	2.47	
	B2P	2.75	2.65	
	4P	3.84	2.75	
F Value	6.5	6.5(3/44)	4.35(3/28)	
Level of Sig. (p =		.001	.01	

3.10. Discussion of Results. The results will be examined to answer two main questions: what kinds of development, if any, occur with age in the performance of a sentence/

picture verification task and at what ages do the various aspects of efficient performance come to be perfected? The results will be addressed to see if development is best characterized in terms of a growing awareness of the need to extract only relevant information from the array, of the form that relevant information can take and of a developing capacity to extract only that information. Alternatively development may be best seen, not in terms of the recog-bition and extraction of relevant information, but rather in terms of faster matching of the sentence and array des-criptions at a more central level once the relevant infor-mation has been received. Assessing the appropriacy of these two possible descriptions of the development of sentence/picture verification processes requires considera-tion of whether one or other of the descriptions is approp-riate for most groups over all conditions or whether both are necessary. Since the age factor proved significant for most conditions, at least in terms of the RT and Number of EM measures, it can be granted that there is some develop-ment to be explained.

For the 1P Condition it would seem at first glance that the "central processor" (CP) description might be most relevant since there were no significant differences between the groups in terms of AFEMs nor EM patterns although there were differences in terms of RTs and Number of EMs. Thus it would seem that differences in RTs could not be easily explained in terms of the way the information was extracted from the array. Rather it might be suggested that the pre-school children were slower in generating and comparing the array description with the sentence description, and that more EMs were made by the younger Ss because there was more time available during which the Ss just happened to continue to make EMs to other locations - EMs which served no function for the task at hand. This view of the Ss performance could also be held to account for the difference in the number of EMs made on T and F trials, provided that one agreed with a sentence verification model such as Clark's (1972) where true judgements are assumed to be made more quickly at a central level.

Alternatively, more time might be available to the younger Ss to make EMs because of slower motor responses in signalling the decision. However this explanation could not account for differences between true and false trials nor for differences between conditions with different numbers of irrelevant pictures in the array.

A CP description would also need to assume that any information gathered after the relevant information had been selected and processing commenced would be held in store until a judgement had been made. Otherwise the processing of any additional information might be taken to interfere with the comparison process and any delay in processing attributed to the failure to inhibit irrelevant EMs rather than to central processes. Moreover, even if EMs made after the relevant information had been located can be assumed to be held in store, irrelevant information processed before the SPL has been located must delay the beginning of processing. Thus any inappropriate FEMs must contribute towards longer RTs unless other time parameters are altered.

The CP description would be supported by Amades and Shagass (1963) who, in order to find ways of characterizing the changes in attentive functioning associated with the hypnotic state, conceptualized EMs as being a nonspecific concommitant of attentive activity and predicted that EMs would occur more frequently in association with heightened attention whether or not specific imagery was involved. Their claim was supported by their finding an increase in the number of EMs made during a word-association test over the number made during a rest period, which was taken as the base rate. This also occurred during a specific imagery task and while the Ss carried out an arithmetic task. However all these comparisons were made between situations where Ss had their eyes closed.

Weitzenhoffer and Brockmeier (1970) challenged Amades and Shagass's generalization of their findings to cover the relationship between "degree of attention" and EM rate for a whole variety of situations. They proposed that for many tasks which called for a focussing of attention there would be no increase or else a reduction in the EM rate. Their findings supported the conclusion that the nature of the task and the general situation under which it is formulated and executed all affect the EM rate, even when non-visual tasks are involved. They reported that the reduction in EM rate found to occur with "resting eye closure" was of the same order as the reduction in EM rate observed in association with the performance of the attention producing tasks with eyes open. They made a strong case that many visual situations will involve some "conscious, voluntarily established set for selective responsiveness". Both Buswell (1935) and Yarbus (1967) also favoured the view that longer duration of fixations (and hence fewer fixations over a given time period) indicated some increase in the information load.

In fact, eye closure as well as looking at blank areas was an option open to all the Ss in the present studies in order to ignore irrelevant information while making the judgement and yet only three Group 1 Ss, one Group 2 S and one Group 4 S were observed to do this on one or two trials each. Even in these cases the Ss had already made a thorough examination of the array prior to closing the viewing eye. The fact that Ss' strategies did not seem to include these options suggests that where it occurred, further scanning was part of a fairly specific purposive activity which involved finding the mentioned picture.

If Ss do continue to make EMs for as much time as is available while central processing is carried out, but make them without reference to the task, then there is no reason to expect the Patterns, Number of EMs or RTs to differ between F+ and F- trials. But this is what happens under the 1P Condition, where F- trials take longer, elicit more EMs and fewer ES patterns than do T or F+ trials which do not differ in terms of any of the measures as might be predicted from the CP description. Although Group 1 Ss made more EMs on F- trials than Group 2 Ss, both groups failed to recognize the absence of any picture as evidence for a false judgement. It would seem more likely that longer

RTs were found on F- trials because more EMs were made rather than vice versa.

Apart from their performance on F- trials, children as young as four years were able to carry out efficient searches provided that the only picture present was in the SPL, making the selection of relevant from irrelevant information unnecessary except in the sense that vacant irrelevant locations were not to be inspected before the relevant occupied location. Thus on T and F+ trials, improvement in central processing needs to be involved to explain differences in RTs and EMs between the groups.

The performance of Ss under the 4P Condition provides more evidence for developing efficiency in terms of the "Recognition and Selection" (RS) description. For the 4P Condition the Teenage and Adult Groups were better able to constrain their FEMs and EM Patterns according to the demands of the task than were the two younger groups. Thus part of the improvement in RTs and No.EMs found for the two older groups was possibly due to development in the ability to anticipate and carry out "projected" searches for relevant information and to cease search once it has been found. For the two younger groups the search is anticipated to a certain extent inasmuch as no differences were found between the number of Ss making AFEMs on T and F+ trials when there was a picture in the SPL, but the search is not fully pre-programmed and requires some visual stimulus to attract the FEM, since on F- trials Groups 1 and 2 were particularly poor at making AFEMs.

It would seem that the realization of what comprises relevant information is differentially acquired for true and false judgements since there was a significant interaction between groups and truth value for both the AFEM and No.EM measures taken on the 4P Condition. Also, significant differences were found between each of the truth values in terms of the ES and NES2 Patterns, with more Ss making the most efficient pattern on T trials than on F+ trials and than F- trials, whereas the reverse order was found for the most inefficient pattern. The search strategy of the two younger groups does not seem to involve looking at the location mentioned and ascertaining if the specified picture is present or absent. Rather their strategy seemed to be to search for the specified picture either in the SPL or elsewhere, in order to generate a description of where the object is located and to compare this description with that to be judged. In other words, the younger S found it easier to compare 'The dog is at the bottom' with the given sentence 'The dog is at the top', than to compare 'The hen is at the top' with the given sentence 'The dog is at the top'. When searching an array in order to generate an array description to use as input for the comparison process, the young S tries to maintain the identity of the picture rather than the specified location or relationship. When the specified picture was not present in the array, the young Ss needed to make fewer EMs when another picture was in the SPL than when no picture was there at all.

Confirming evidence for the importance of finding the specified picture, even for adult Ss, comes from a study by Carpenter and Just (in press) which required adult Ss to verify phrases like 'Isn't East' and 'East', which referred to the location of a plus symbol (+), against an array very similar to that used for the 4P Condition, except that asterisk and plus symbols were used and the sentence was presented in the centre of the array to be read prior to search. It was found that the amount of time spent fixating other locations was determined by whether there was a plus in the location mentioned in the sentence. The duration of fixations on other locations was longer when there was no plus in the location mentioned as was the case for the false affirmative and the true negative sentences.

In the present study such information about the duration of the fixations at various locations was not available. However, what was found was that the differences found on other measures between the trials differing in truth values were not translated into significantly large differences in RT, even though there was a tendency for RTs to be ordered in a way that corresponded to the ordering of other measures. It would seem that to some extent the Ss were able to deal with the different truth judgements and making different No.EMs by making more but shorter fixations on F trials. This would make sense in terms of a serial processing model of perception which would propose that mismatches are detected more quickly than matches.

Another factor which probably interacts with the growing appreciation of task defined relevance in leading to more efficient performance, is the development of ocular motor skills which would allow the S to maintain fixation at or about the relevant location, regardless of information from images of pictures falling on the periphery of the retina. The adult may perform better because he or she can not only plan where to look and direct his eyes to fixate that position but can also maintain fixation on that location and inhibit further large EMs until sufficient information has been gathered to make a decision. However, such development in itself does not account for the acquisition of the ability to make ES patterns firstly on T trials and only later on F+ trials and finally on F- trials.

For the 2P and B2P Conditions there were no differences between the groups in terms of AFEMs although the difference between Groups 1 and 2 nearly reached significance at the .05 level for the B2P Condition. The 2P data was unique inasmuch as even the adults did not make significantly more AFEMs than the Group 1 Ss. So for all groups there was room for further improvement in searching directly for the relevant information. For the younger groups there was also room for improvement in terms of fewer EMs and faster RTs, since the adults were able to make fewer EMs and faster decisions even though inappropriate FEMs were made. This was because once the adults had located the relevant location they were less likely to refer back to the other location as can be seen by the difference in the number of NES2 patterns made by Group 3 Ss and those made by the two younger groups. The same pattern of results occurred over the various measures for the B2P Condition, suggesting that either the Ss were treating trials on the 2P Condition as binary, or else that the Ss did not regard the pay-off as being sufficient on any 2P trials to constrain their search.

When comparisons were made between age groups for each condition it was found necessary to formulate a description of the Ss performance which took into account development by children up to nine or ten in terms of the recognition and selection as well as the processing of relevant information. However, when conditions were compared across groups from the same age range, neither the R&S nor CP descriptions could completely account for the fact that while differences in AFEMs, Patterns and Number of EMs were found between conditions for all groups, no differences were found between conditions in terms of RTs for groups from the pre-school and school age ranges.

For adults only the 2P Condition differed from the 1P and 4P conditions, and this was reflected in terms of every measure. Thus when more FEMs were inappropriate, more inefficient patterns and more eye movements were made and the RTs were also longer, but when no differences were observed between the AFEMs, patterns and number of EMs, as was the case with the 1P and 4P conditions, no differences in RTs were found either.

For groups drawn from the pre-school and school age ranges, differences were found between the 1P and the rest of the conditions on the AFEM and Patterns measures, but there were no corresponding differences in terms of RTs nor in terms of EMs when all the sorts of trials were considered.

When differences between conditions were analysed in terms of the RTs and No.EMs for T and F+ trials only, differences were found between conditions in terms of No.EMs for both age ranges but not between conditions in terms of RTs. It was felt that such an analysis was justified because the large number of EMs made on F- trials on the 1P condition (the only trials on which no pictures at all were present) may have been masking differences occurring between conditions on trials when at least one picture was present.

It would seem that Ss from the two younger age ranges are able, within their own processing limitations, to compensate for inefficient searches by spending less time on each fixation. But in order to make performance more efficient than this strategy will allow it is necessary for the child to change his search strategies and his ways of encoding relevant information. This does not seem to be achieved until the beginning of the teenage years, which, co-incidentally, are recognised as the beginning of the stage of formal logical reasoning as described by Inhelder and Piaget (1958). Although as yet no more than speculative links may be postulated to exist between the growth of systemmaticity in terms of formal logical operations and the growth of systemmaticity in terms of visual search, it is an area worthy of further examination.

Finally, it is worth noting that for no age group nor for any condition, except for the 1P Condition, was one specified position more amenable to being searched or judged with more efficiency. There was no evidence to support Seymour's (1969) contention that people will tend to scan an array from the top to the bottom even when verifying a statement about one picture being below a given reference point. The findings are more in keeping with Chase and Clark's (1971) suggestion that any difference in verification time will occur at the interpretation stage of the sentence to be judged. Since the sentences were always presented prior to the arrays for all conditions in the present studies, it is not surprising that no differences were found in the ability to direct FEMs immediately to the bottom or the top. What is interesting is that the sentence verification task was able to constrain the youngest Ss to overcome any tendency to spontaneously scan an array of two vertically arranged pictures from top to bottom as Levy-Schoen (1971) had found. It is unlikely that this can be attributed to the presence of the lights at the bottom and sides of the box but not at the top, since four subjects of pre-school age who were presented with arrays of the kind given for the T and F+ trials in the 4P Condition, but without the constraint of having to judge a sentence, made only 15.6% of their FEMs to the bottom and 21.9%, 25% and 37.5% of their FEMs to the top, left and right picture locations respectively.

3.11. Summary: These studies of the ability of subjects of different ages to judge sentences concerned with spatial relations against various kinds of visual arrays, reveal an interesting developmental trend in the extent to which subjects allow linguistic and cognitive task constraints to direct their visual search patterns, rather than being susceptible to the presence and location of stimuli in the visual field.

For even the youngest subjects of 4 years, the sentence was sufficient to direct their visual search appropriately and efficiently, provided that no irrelevant stimuli, in terms of the task, were present in the field. This proved to be so even when no stimulus was present in the location that needed to be searched in order to judge the sentence. However as soon as one or more irrelevant pictures were introduced into the visual field the ability of children up to 10 years to make AFEMs was reduced, especially when no picture was present in the relevant location.

Teenagers and adults were more able to make AFEMs despite the presence of several irrelevant pictures, provided that a picture was present at the relevant location. Only adults were sufficiently aware of the task constraints to anticipate and pre-set the necessary search pattern so that it was carried out even when no picture, which may have seemed to "attract" the gaze, was present at the SPL. Even the ability of teenagers and adults to make AFEMs was somewhat reduced when only one, rather than several irrelevant pictures were present in the array. This was attributed to some factor such as the necessity for a minimum number of irrelevant pictures to be present before the need for efficient search was recognized even by the older subjects.

It would seem that the development of the ability to voluntarily direct visual searches proceeds in such a way that, initially, the presence and probably the properties of the stimuli in the visual field are most influential in determining where the subject will look, although cognitive task constraints can come into action when no visual stimuli are present. The next stage, which extends over quite a long period of time, involves an interaction of the task and perceptual constraints such that, provided a stimulus is present in the expected location, then the visual system will have been sufficiently pre-set by the task to be triggered and attracted by this stimulus rather than any other. However, when no stimulus is present at the expected location then the presence of any other stimuli will be sufficient to overcome any planned eye movement in the appropriate direction. Although the ability to plan specific visual searches increases with age it is not until the adult years that the subject has acquired some degree of proficiency in directing his eye movements in terms of only task defined constraints.

This conclusion was also drawn from an examination of the effect of irrelevant stimuli on the search patterns of subjects of various ages which indicated that with increasing age subjects were better able to ignore irrelevant pictures and to focus only on the relevant picture location. This was attributed both to the manner in which the subjects sought to represent the visual array and also, partially, to an inability to inhibit unnecessary eye movements which were presumably made because the gaze was attracted involuntarily to the irrelevant stimuli. Because of the significant interaction effect of age and truth value of sentence that was found in several experimental conditions, it was argued that the younger child preferred to judge the sentence by generating a description of the visual array which was constructed in terms of the picture referred to in the sentence, but not in terms of the relationship specified in the sentence. This fits with the fact that for most conditions children judged true sentences after fewer eye movements than they had made for judging F+ or F- sentences. For teenagers and adults the difference between the mean No.EMs taken to judge T and F+ or F- sentences was not nearly so marked as for the pre-school and school children. This suggested that either the older subjects were able to search the arrays selectively and recognize both falsifying or verifying evidence or else they were able to generate a description of the relevant part of the visual field in terms of either the picture or the relationship referred to in the sentence. If this was the case fewer eye movements would be made in an attempt to find the mentioned picture, thus reducing the No.EMs made before a judgement . This was what was found.

The results also provided a check on the conclusions drawn by Chase and Clark (1971) who attributed the differences found in the judgement times for 'above' and 'below' spatial locations to differences in the coding time required for the words and not to a tendency to scan arrays in a top-down direction as suggested by Seymour (1969) in an early paper. However Seymour later came

(1973, 1974a) to agree with Chase and Clark that the top-down scanning hypothesis did not fit the available evidence,but he again challenged the adequacy of their explanation proposing instead that the results of various experiments were consistent with a response availability model, which assumes that differences in verification times occur because of momentary adjustments in thresholds for selection of yes or no responses which occur as the encoding of the display proceeds. Seymour (1974b) did not accept that sentence (or word) and picture encoding operations are truly independent operations but found it preferable to think of the representation of the sentence "in terms of a semantic representation in which object features and spatial relationships are specified and which may provide a basis for construction of efficient plans for verifying test sentences" (p.50).

The findings from studies discussed in this chapter provided no conclusive evidence that sentences describing the 'bottom' spatial relationship take longer to verify than those describing the 'top' relationship. In fact the only relevant significant finding suggested that bottom locations might be more efficiently searched. It was speculated that this may have been due to a reduction in the number of potentially distracting stimuli in the visual field. There was certainly no evidence that subjects carried out stereotyped visual searches of simple arrays without reference to the sentence to be judged. However this was not seen as automatically lending support to Seymour's response availability model nor to Clark and Chase's view that RT differences were due to differences in forming semantic representations for different words or sentences. It was concluded that it was only by examining the actual visual search patterns that their role in the verification process could be properly explored.

On the basis of the results it was argued that any model of sentence/picture verification processes which only sought to describe and make predictions about central processing mechanisms could not properly account for the development of the ability to judge verbal descriptions against the visual world. This was because a substantial amount, though not all, of the improvement with age in performance of a sentence verification task resulted from changes in the form in which the subject seeks to describe the world, the way the subject recognizes what constitutes falsifying evidence, and the ability of the subject to anticipate and carry out efficient visual searches without being distracted by irrelevant stimuli.

CHAPTER 4

Three Preliminary Studies Providing a Frame of Reference for the Active/Passive Eye Movement Study

Introduction: Before reporting the active/passive eye movement study in Chapter 5, several preliminary studies will be presented. The first of these studies was carried out to ensure that children of the age group represented by the youngest subjects were able to carry out an appropriate manual search for a hidden picture in order to verify either an active or a passive sentence. The second study was carried out to discover any biases in the visual search patterns made by subjects who were not subjected to the constraints of a specific linguistic task but simply required to tell the experimenter what they could see of a visual array. The third preliminary study was to ascertain whether subjects were able to carry out an appropriate visual search in order to verify active sentences. This was to ensure that eye movement measures would provide a reasonable way of comparing active and passive sentences.

4.1. Manual Search Strategies in the Verification of Active and Passive Sentences.

Introduction: This study was to ascertain if young subjects were able to select the appropriate direction in which to search to verify active and passive sentences when there are no visual distractors in the immediate visual field.

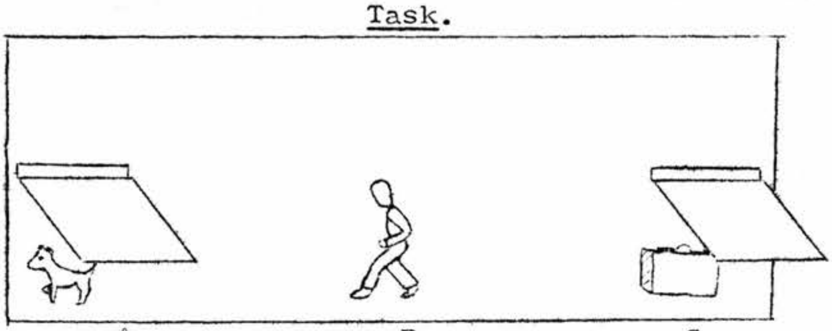
Subjects: Sixteen children ranging in age from 3;5 to 5;0 years were recruited from local nurseries for this experiment.

The mean age of the children was somewhat lower than that of the children taking part in the visual search sentence verification task. This was due to the fact that the time of experimentation coincided with the commencement of the nursery school year when there were few older nursery school children available. However if the younger subjects were able to perform the task then it was felt that the older children would also be able to cope. The subjects were divided into two groups, Group A having a mean age of 4;0 years and Group B having a mean age of 4;5 years.

Experimental Task, Design and Instructions: The subject was asked to verify a simple active or passive sentence against an array which consisted of three pictures spaced equally along the bottom of a sheet of paper placed directly in front of the subject. The central picture, labelled B, was drawn in profile and was uncovered while the other two pictures, labelled A and C, were each covered by a flap of paper which could be raised by the subject (see Diagram 4.1.). As in the active/passive sentence verification eye movement study the logical subject of the sentence to be verified referred to the picture in the B position.

Diagram 4.1.

Example of Arrays Used in Manual Response Sentence Verification Task.



A Picture | B Picture | C Picture

Each subject had to verify eight sentences, four of them active and four passive. The number of true and false sentences was balanced across the voice condition. Group A subjects received sentences requiring them to look to the faced side of the uncovered pictures, while Group B Subjects received sentences which required them to look to the 'unfaced' side of the uncovered picture. Group A and Group B sentences are listed in Appendix 4.1.

Subjects were given the following instructions: "See the picture (E points to B). See these windows (E points to A and C). There's a picture hidden under this window and a picture hidden under this window (E lifts up flaps to show pictures at A and C). In this game I'm going to tell you about some of the pictures. You have to open one of the windows. Now, listen. See the B picture - well I think 'the B picture is ----'. You find out if that's right or wrong. I think '(Repeat of test sentence)'. You look and see."

The window chosen, the judgement made, and the reason for the judgement were noted by the experimenter.

Results: The inappropriate window was only selected on four out of 60 trials by Group A subjects. These errors, which were made by three subjects, were made on passive sentences. The four manual search errors of the 64 trials carried out by the Group B subjects, were made by three subjects. Two errors were made for active and two for passive sentences.

So while passive sentences seemed slightly more difficult than actives in terms of the appropriacy of the search strategy employed, most children seemed to be able to use both fairly well in order to direct their manual search. However it should be noted that the scores of three children were not included in the analyses of the Group B results. The strategy of these children was to consistently choose the left-hand picture. One child occasionally gave an appropriate judgement on the basis of the picture but the other two children did not. These children showed no evidence of being constrained in their search by the linguistic task. One of these children was a twin whose language development had been previously noted as slower than that of his peer group. The other two children were independently described by their nursery teacher as coming from severely disadvantaged backgrounds while none of the rest of the experimental group was so described. Even if the scores of these children had been included in the analysis, there would have been no significant difference in the number of errors made for passives as compared with actives.

It was decided that children as young as four years could reasonably be asked to carry out the same sort of task in a more complex experimental situation where their EMs could be recorded.

4.2. Eye Movements in Response to Non-Specific Verbal Instructions. In order to investigate whether or not subjects would be biased to look in the faced direction of the FFP, the possibility of which was discussed in Chapter 2, the following experiment was carried out.

Subjects: Ten 4 to 5 year old children (mean age, 4;5 years) and eight adults, none of whom were used in any other EM study, took part in this experiment.

Experimental Task and Design: The task and procedure were the same as for the other EM studies except that the S was not required to judge the truth value of a sentence against a pictorial array, but was instead instructed by the E to "Look at the pictures and tell me what you can see." It was felt that these instructions were sufficiently precise to direct the S's attention to the pictures but sufficiently loose to allow the S to interpret each array as they preferred, either as a number of separate pictures or as a number of pictures related in some specific way.

Each S was required to view sixteen arrays, each consisting of three pictures and arranged in the following fashion. One picture was located just above the camera hole, a little above the 'straight ahead' line of regard of the S so that the S's eyelid should be slightly raised and the eye more exposed to the camera during the visual search. This picture location was labelled 'B' and it was this position which the S was instructed to first fixate by looking at the luminous green spot placed on whichever picture was located at B. Two other pictures were located at an equal distance from B, one to the right and one to the left, so that all three pictures rested along a horizontal base line. These locations were labelled 'A' and 'C' with A being to the right of B and C being to the left of B, as seen by the S. For each array the pictures placed at A and C were equated for size and similarity in general outline, so that the angles subtended by the distances between the inner and outer boundaries of the pictures at A and B were the same as those subtended by the distances between B and C pictures. The average sizes of the EM required to look between the inner boundaries of two adjacent pictures or the outer boundaries of two adjacent pictures were $12^{\circ}53'$ and $18^{\circ}56'$ respectively. The average size of an EM between pictures at A and C was $27^{\circ}12'$ between inner boundaries and $32^{\circ}8'$ between outer boundaries.

The picture at B represented an object, usually animate, seen in profile so that the direction in which the object was facing was not in doubt even to the youngest Ss. The other two pictures also often represented objects in profile. There were an equal number of arrays with the FFP at B facing right and left. Half the Ss in each age group inspected the arrays with their left eye and the other half used their right eye.

Procedure: The experimental task and procedure were the same as for the other eye movement studies except that the subject was not required to judge a sentence against the array, but instead was instructed by the E to: "look at the pictures and tell me what you can see." It was felt that these instructions were sufficiently imprecise to allow the S to interpret each array as they preferred, either as a number of separate pictures, or with the pictures related in some way.

Scoring and Analyses: The EMs for the S were again recorded on videotape and scored for the direction of the FEM. These scores were analysed so as to ascertain

1) the percentage of FEMs which were made in the faced direction of the FFP at B

2) the percentage of FEMs made by subjects to the right or left of the FFP according to the eye being used to view the arrays.

Results and Discussion: As can be seen from Table 4.2.1. the young children looked in the faced direction of the FFP on 50.6% of all trials. Four children made 'faced' responses on more than half of the trials, three children made faced responses on less than half of the trials, while three children made an equal number of 'faced' and 'unfaced' FEMs. All children simply listed the pictures in each array for most of the trials. So when no specific verbal instructions were given the children showed no tendency to make their FEM in the 'faced' direction of the FFP. The increased percentage of FEMs in the 'faced' direction shown by the adult Ss can be mainly accounted for by the scores of two adults who reported what they saw in terms of related rather than separate pictures.

TABLE 4.2.1.

Frequencies and Percentages of FEMs in the Faced Direction of B.

	Frequencies	Percentages
Children	78/154	50.6
Adults	84/128	65.6

The direction of the FEMs according to the viewing eye is shown in Table 4.2.2. and reveals an interesting pattern of results. For both the right and left eyes the children showed a slight preference for looking left which is in accordance with Levy-Schoen's findings for children of this age. However the adults showed a slight preference for looking right with the left eye and a greater preference for looking left with the right eye.

TABLE 4.2.2.

Percentages of FEMs to the Right and Left of B for Right and Left Eye Subjects

	Right Eye Subjects		Left Eye Subjects	
	REM	LEM	REM	LEM
Children	41.9	58.1	41.2	58.8
Adults	29.9	71.1	54.7	45.3

Discussion: The children looked in the faced direction of the FFP on 50.6% of all trials. Four children made faced responses on more than half their trials, three children made faced responses less than half the time and the other three were equally divided. All children simply listed the pictures they saw for most of the arrays. So without specific verbal instructions the children showed no tendency to make their FEM in the faced direction of the FFP. For both the right and left eyes the children showed a slight preference for looking left, which is in accordance with Levy-Schoen's results.

The increased percentage of FEMs in the faced direction showed by the adults can be accounted for by the scores of two adults who reported what they saw in terms of related rather than separate items. The direction of the FEMs according to the viewing eye, reveals a very interesting pattern for the adults. The adults showed a slight preference for looking right with the left eye, but a more considerable preference for looking left with the right eye. This might reflect an interaction of "eye-edness" and "reading habits", or alternatively the effect of one picture falling on the blind spot, although one would have expected this effect to be the same for the two eyes.

In order to show that the specific linguistic instructions used in the sentence verification tasks can constrain the EMs of subjects in particular ways, the number of EMs made in the faced/unfaced directions must vary significantly from the levels found in this study.

4.3. Active Sentence Verification Eye Movement Study. This study was carried out to ensure that it was feasible to compare children of different ages on a variety of measures of their performance on a task requiring horizontal EMs in order to search for evidence to verify a sentence.

Subjects: Subjects were selected and trained in the manner described in 2.2. The subjects were divided into four groups, three containing eight subjects each, while the adult group was only given a token representation by two females. The other three groups contained an equal number of males and females. The mean ages and range of ages for each group is given below.

Groups	Mean Age (in years and months)	Range of Ages
1	4;8	4;2 - 5;0
2	8;9	5;9 - 11;2
3	13;8	12;0 - 14;8
4	23;0	21;0 - 25;0

Task and Procedure: The form of the experimental task and the procedure were the same as for the active/passive study as described in 5.3 and 5.5 except that all the ten test sentences to be judged were in the active voice, for example: "The boy is chasing a dog".

Design of Experimental Trials: Each subject was presented with ten sentences each to be judged against a pictorial array. Eight of the sentences were constructed as four pairs, both members of a pair describing the same relationship between the two critical pictures in the 3-picture arrays. Thus two sentences described a "chasing" relationship (Pair 1), two "looking" (Pair 2), two "watching" (Pair 3) and two "running away" (Pair 4). Each member of the pair used a different logical subject and logical object to refer to the relevant pictures in the arrays against which it was to be judged. One sentence in each pair was true of its array and one false of its array. One required the subject to look to the right of the FFP and one required the subject to look to the left, in order to verify the sentence in the most efficient way. The truth value and appropriate direction of search were balanced across the pairs. Three of the pairs of sentences required the subject to look to the 'faced' side of the FFP, while one pair required the subject to look to the 'unfaced' side. The sentences were then divided into two groups, one member of each pair being assigned to each group so that there was one true left, one true right, one false left, and one false right trial in each group. One group was labelled Group A and one Group B. A full description of the sentences and pictures used in the arrays, is given in Appendix 4.2. For each array the pictures were arranged in the manner described in 4.2.

In order to balance the order of presentation of the trials, half the subjects in each group received Group A and then Group B trials and the other half received the reverse order. Half of each group of subjects used their left eye and half used their right eye to view the arrays.

These eight trials provided most of the data for the various analyses. However each subject received two additional trials after both Group A and B trials had been presented. In these trials, both faced, the sentences were false in a binary fashion of the arrays they were meant to describe. This was because the picture referred to by the LO of the sentence was present in the array but was not related to the LS picture in the manner specified by the sentence. One binary (B) trial required the subject to look left and the other required him to look right to search efficiently.

Scoring and Analyses: The EM records were scored in the manner described in Chapter 2.2. The RTs and judgements made on each trial were also noted. The RT and number of EMs measures for the first eight trials were each analysed by means of a Three-way Analysis of Variance with repeated measures on two factors in order to ascertain the effects of age, truth value and the particular pairs of sentences used. The AFEM and EM Patterns measures for the same trials were analysed respectively by means of a Three- and Four-way Partitioning of Chi-square to examine the effects of the same factors as well as the kind of patterns employed. For these analyses the Age Factor was examined only in terms of Groups 1, 2 and 3, although the mean scores for the two adults on the four measures were ascertained and are mentioned in the results when they are appropriate for the purposes of comparison.

A Three-way Partioning of Chi- quare was carried out comparing the AFEMs made on the two binary false trials given to each S at the end of the other trials, with two non-binary false trials which were equivalent in the sense of describing the same relationships.

Individual Comparisons were made by means of the

Tukey test for RT and EM measures and the Wilcoxon and Kolmogorov-Smirnov Tests for the AFEM and Pattern measures.

On the four trials where inappropriate judgements were made once (on three occasions by a Group 2 S and on one occasion by a Group 3 S) the scores for the repeat of the trial were used.

Results: The main results for the eight trials in terms of the four measures have been summarized in Table 4.3.1. The most important points to be established by the results were that all of the Ss were able to cope with judging the sentences and that there were some changes in performance with age in the direction of more efficient performance of the task.

From Table 4.3.1 it can be seen that the older the S the less time was taken, fewer EMs were made and more ES patterns were made in order to verify active sentences. Group 1 Ss were significantly (p = .05) slower in making a decision than either Group 2 or Group 3 Ss who did not differ significantly from one another although Group 3 Ss tended to be faster than Group 2 Ss. The adult Ss mean RT (1.53 sec) was slightly faster than that of the teenage Ss. The No.EMs made also decreased with age with Group 1 Ss making significantly (p= -05) more EMs than Group 3 Ss. Group 2 Ss did not differ significantly from either Group 1 or 3 Ss in terms of Number of EMs. The mean No. EMs made by the adult Ss (2.56) was slightly smaller than that of the Group 3 Ss.

The mean number of Ss making ES patterns was significantly (K_D=5,6 N=8, p=.05,.01) greater for Group 3 Ss

TABLE 4.3.1

Factors Affecting Judgements of Active Sentences in Terms of Four Measures

Measure	Comparison	F or χ^2 Value	df	Level of sig.		Mean Score			
AFEMs	Truth Value (TV) (T,F)	-	-	NS		4.92 v 5.33			
	Age (Groups 1,2,3)	-	-	NS		4.75 v 5.12 v 5.50			
	Trial Pairs (1,2,3,4)	14.72	3	.01		5.50 v 6.83 v 6.00 v 2.17			
EM Patterns	Patterns (ES,SES, NES1,NES2)	76.6	3	.001		ES	SES	NES1	NES2
						1.54 v	1.25 v	4.17 v	1.04
	Patterns x Trial Pairs	18.71	9	.05	1	1.00	1.67	3.83	1.50
					2	2.00	1.17	4.00	.83
					3	2.83	1.17	3.83	.17
					4	0.33	1.00	5.00	1.67
	Patterns x Groups	12.62	6	.05	G1	1.37	1.37	4.00	1.25
					G2	0.62	1.75	4.37	1.25
					G3	2.62	0.62	4.12	.62
	Patterns x TV	7.90	3	.05	T	2.00	1.17	3.58	1.25
					F	1.08	1.33	4.75	0.83
RTs	TV	-	1/4	NS		2.40 v 2.71			
	Trial Pair	3.57	3/12	.05		2.92 v 2.31 v 2.34 v 2.99			
	Groups	6.03	3/12	.01		4.15 v 2.31 v 1.65			
No EMs	TV	-	1/4	NS		3.37 v 3.17			
	Trial Pairs	5.65	3/12	.05		3.62 v 2.59 v 2.88 v 3.71			
	Groups	4.71	3/12	.05		3.75 v 3.34 v 2.73			

than for Group 1 and 2 Ss respectively, but Group 2 Ss made fewer ES patterns than either Group 3 or Group 1 Ss. No explanation is readily available to explain the poorer performance of the older children compared to the pre-school children. Adults were more likely to make ES patterns than the other groups as can be seen when the percentage of ES patterns are compared across the age groups from Group 1 to Group 4: 18.1%, 8.2%. 33.3% and 43.7%.

Another way of expressing the greater efficiency of the Group 3 and 4 Ss is given in Table 4.3.2. where the percentages of Ss making both sorts of efficient patterns (ES and SES) have been compared against both sorts of inefficient patterns (NES1 and NES2) when the Ss from Groups 1 and 2 are combined and compared against Groups 3 and 4.

TABLE 4.3.2

Percentages of Two Efficient and Two Inefficient Patterns Made by Groups 1 and 2 and Groups 3 and 4.

	Groups 1 and 2	Groups 3 and 4
ES and SES	32.8	44.4
NES1 and NES2	67.2	55.6

Other significant effects found in terms of the EM Patterns measure included the kind of pattern made, with significantly more NES1 patterns being made than ES, SES or NES2 patterns respectively ($T=38,33,34$, $N=16,19,21$, $p=.05, .02, .01$). A Patterns by Pair of Trials interaction indicated that significantly more NES1 patterns were made on Pair 4 trials than on Pairs 1, 2 or 3 respectively ($T=57,59, 49$, $N=22,22,20$, $p=.05$ for all values). Also more NES2 patterns were made on Trial Pairs 4 and 1 than on Trial Pair 3 with the smallest difference between the trials being significant at p=.02 (T=30, N=18). A Patterns by Truth Value interaction showed that a significantly larger difference occurred between F and T trials in terms of NES1 patterns than occurred with SES patterns. As can be seen, the teenage and adult Ss make almost an equal proportion of efficient and inefficient search patterns whereas the younger Ss make twice as many inefficient search patterns as efficient patterns.

The ability of Ss to direct their FEMs in accordance with the constraints of the task, as indicated by the mean number of Ss from each group making AFEMs, was lower than expected, at least for the older groups. This can be accounted for by the fact that the scores for Trial Pair 4, which required an AFEM in the "unfaced" direction from the FFP were significantly (T=21,10,17, N=23,23,21, p=.01 for each comparison) lower than for the other three trial pairs 1,2 and 3 respectively and had depressed the AFEM scores for all groups of Ss. An examination of the percentages of AFEMs made on each of the three "faced" pairs of trials, given in Table 4.3.3 for each group of Ss, shows that while age differences were small, the level of performance was well above the base level found for non-directed search as reported in the previous section, 4.3. It was thus decided that "faced" active sentences would provide an adequate comparison for subjects' performance when judging passive sentences.

TABLE 4.3.3

Comparison of Percentages of AFEMs Made by Each Group for Each Pair of Trials.

Groups	Pair 1 Chasing	Pair 2 Walking	Pair 3 Looking	Pair 4 Running Away
1	75.0	75.0	68.7	18.75
2	66.7	81.0	66.7	53.33
3	68.7	100.0	68.7	37.50
Mean for All Groups	70.1	85.4	68.1	36.5

The fact that no significant differences were found between the AFEM scores of the different age groups may be either due to the possibility that even the youngest Ss were as good as older Ss at directing their FEMs in the "faced" direction, or else due to the possibility that the Ss were not presented with enough trials to allow for the development of a well-formed strategy.

Since it seems likely that the older Ss would be more able to develop an appropriate strategy given a chance, the provision of additional trials would be expected to benefit the older Ss more than the younger Ss at least in terms of the AFEM Measure.

The ability of Ss to make AFEMs seemed to influence other aspects of their performance inasmuch as for every age group more EMs were made on trials where an IFEM had been made than on trials where AFEMs were made, as can be seen by inspection of Table 4.3.4.

TABLE 4.3.4

Comparison of Mean No. EMs Made on Trials When AFEM Occurred and on Trials When IFEMs Occurred

	Group 1	Group 2	Group 3	Group 4
AFEM	3.47	3.12	2.43	1.43
IFEM	4.15	3.80	3.42	1.71

One further point which supports the design of the task is that no evidence was found to suggest that the S's search strategies are initially guided by the presence in the array of the picture referred to by the LO of the sentence. No significant differences were found between the mean number of Ss making AFEMs on non-binary and binary false trials (5.83 v 4.67), nor were any differences found between true and false non-binary trials in terms of the mean number of Ss making AFEMs.

When the effect of other factors apart from age is considered, truth value only had an effect in terms of the Pattern measure, with significantly ($p=.05$) more ES patterns being made on T trials and significantly ($p=.05$) more NES1 patterns being made on F trials. There were no differences between true and false trials in terms of RTs or No.EMs made. With respect to the RT measure this corresponded to the finding reported in Chapter 3 that T and F+ trials did not differ in terms of RTs when only one irrelevant picture was present, as in the 2P Condition.

The particular relationship to be verified seemed to affect both the RTs and the No.EMs made by the Ss who took significantly ($p=.05$) more time and more fixations to verify "chasing" and "running away from" trials than to verify "walking" and "looking at" trials. The Pairs of Trials also interacted significantly with Patterns, with significantly ($p=.05$) fewer ES patterns and significantly ($p=.05$) more NES2 patterns being made for Pairs 1 and 4. There was also a tendency for more NES1 patterns to be made on Pair 4 trials than on the other three pairs of trials. One possible reason for this finding may be the 'reversibility' of the "chasing" and "running away from" relationships when compared to the 'irreversibility' of three of the four "walking" and "looking" trials, where the non-animate object of the action was not necessarily acting upon or affecting the agent of the action. However no other studies of sentence processing have found reversibility to affect the processing of active sentences. Another possibility is that the criteria adopted by the Ss for "chasing" and "running away from" involve more critical features than do those for "looking" and "walking", such that it is more difficult to identify the action of "chasing" and "running away" from the static arrays than it is to identify the action of "looking" or "walking".

The "chasing" trials did not differ significantly from pairs 2 and 3 in terms of AFEMs but significantly ($p=.001$) fewer Ss made AFEMs on Trial Pair 4 which required the S to look to the unfaced side of the FFP than on any other pair of trials. It would seem that looking to the faced side was the easier way to begin to search when a relationship was to be verified, but it is possible that the inequality between the number of trials requiring faced FEMs and those requiring unfaced FEMs may have biassed the Ss to search more to the faced side. This issue will be taken up again in Chapter 6.

Summary: On the basis of the findings from these three studies it was deemed worthwhile to proceed with a more detailed comparison of the processes involved in judging the truth value of active and passive sentences when all sentences required "faced" FEMs. It was found that children showed that they could carry out appropriate manual searches to verify sentences; they exhibited no perceptual or habitual biases when making exploratory visual searches; and they showed a development in the ability to make efficient visual searches to verify active sentences. The question remaining to be answered was whether altering the form of the sentence would alter the visual search part of the verification process. Chapter 5 deals with this question.

CHAPTER 5

Eye Movements During the Verification of Simple Affirmative Active and Passive Sentences

5.1. Introduction: This study was mainly concerned to investigate the effect of altering the form of linguistic information on the visual search patterns made in order to verify that information. Alteration of the voice of simple affirmative declarative transitive sentences provided a means of varying the form of the linguistic information in a specifiable way. It is an interest common to many researchers to study how children learn to co-operate with other people in a communication situation by learning to both give and follow linguistic cues specifying which aspects of a situation are being focussed upon. So it is pertinent to investigate children's comprehension of passive sentences within this framework. But it must be borne in mind that further studies are necessary to determine whether eye movement measures can be used to show differences in the amount of 'attention' being paid to any particular aspects of the world referred to by parts of sentences that are marked in various ways as being of importance by the speaker. Grieve (1971) argues that adults recognize that the main function of the passive voice is to shift the focus of interest and emphasis from the logical subject to the logical object of a sentence, although its effect may be modified or reinforced by other linguistic markers such as the definiteness of the article and intonational stress.

Other adult studies have shown that while actives and passives are treated as similar when it comes to judgements of semantic similarity (Clifton & Odom, 1966) and semantic anomaly (Clark and Begun, 1968) they are also treated as being different in very subtle ways.

Johnson-Laird (1968a and b) found that emphasizing the logical subject in active sentences and the logical object in passives caused subjects to emphasize these aspects when constructing or selecting arrangements to correspond to the sentences. Clark and Begun (1968) reported that when subjects had to change one word in order to reduce the degree of anomaly of active and passive sentences, they changed either the verb or logical object for actives and either the verb or logical subject of passives. In other words whatever the "theme" or "topic" of a sentence, it was not seen as the source of the anomaly, but was rather taken as the point of reference from which to restructure the sentence.

The effects of other aspects of the verification task on the subject's performance were also studied. The reasons for including such comparisons as (1) those between true and false trials, (2) those between trials requiring a right or left AFEM and (3) those between trials requiring a FEM in the faced or unfaced direction of the FFP, are discussed in Chapter 2.5.2. However the reasons for selecting a voice comparison deserve fuller consideration which they will be given in the following section.

5.2. Active and Passive Sentence Processing. The effect on various measures of language processing of changing the voice of S.A.A.D. sentence has been studied quite extensively. Early studies (Miller & McKean, 1964) which adopted a transformational approach as a model for linguistic behaviour reported that adults found sentences of increasing transformational complexity, like passives, increasingly difficult to recall. However this general linguistic formulation could not account for the difficulty of negative sentences, which was evidently of a psychological rather than linguistic nature. Other studies like those of McMahon (1963) and Gough (1965) looked at the comprehension of sentences within a referent context and found passives more difficult than their kernel or S.A.A.D. equivalents. This was true, even when, as in Gough's study subjects were given a three-second unfilled delay between the presentation of the sentence and the presentation of the reference situation. This suggests that the subjects were not converting the passives into their equivalent S.A.A.D. representation with an additional note of the passive form.

With respect to a developmental point of view, Bever (1970) argues that a perceptual strategy leads the young child to interpret any noun-verb-noun sequence as corresponding to an actor-action-patient interpretation. The same sort of conclusion was arrived at by Sinclair and Bronckart (1972) who studied the way French-speaking children between the ages of 2;10 and 7 years interpreted three word utterances which were composed of either two nouns and one verb or else of two verbs and one noun. These were presented to the child in every order combination possible and after each presentation the child had to act out the utterance with dolls. It was concluded generally that the developmental trend with utterances composed of two nouns and one verb was for the child to take the first noun as the LS and the second noun as the LO of the utterance.

However a closer examination of the results for those utterances composed of two nouns and one verb which allowed for reversible interpretations, suggested that such a conclusion may be overgeneralising the results. It was only for those utterances given in a N-V-N order that most Ss of various ages tended to take the first noun as the agent and the second as the patient. Moreover, the youngest children (2;10 - 3;11 years) were just as likely to do this as the oldest subjects 6;0 - 6;11 years), while the two intermediate age groups did interpret the first noun as the patient on up to 20 - 25% of occasions. Thus, there was no definite evidence for a development of this particular strategy.

For those utterances where the order of words was N-N-V or V-N-N the Ss of all age groups did not interpret the first noun as agent very much more often than they interpreted it as the patient. A more appropriate conclusion to draw seems to be that when young children have only word order to rely on in order to determine the semantic role referred to by nouns, they do not necessarily rule out the first noun as referring to the patient of the action. Briefly then, the Sinclair and Bronckart study does not provide any firm evidence that when given appropriate marking for a passive, children will not interpret them as passives. Sinclair (1969) briefly mentions an incomplete study in which young children were asked to act out simple active and passive sentences. Some children from 4 to 4;6 years were found to interpret passive sentences in terms of reciprocal actions, while some children interpreted them according to an active word order. However, again no definite conclusion can be made about children's comprehension of passives, this time because of the incomplete data.

Psychological factors such as the reversability of the active and passive sentences to be comprehended, were studied in experiments such as those by Slobin (1966) and Turner and Rommetveit (1967a). These experiments are especially pertinent for the EM studies as they take a developmental view of some of the important factors involved in sentence processing. Slobin gave groups of children (with average ages 6, 8, 10 and 12 years) as well as adults the task of evaluating different sentence types against pictures which were presented immediately upon the completion of the utterance. These sentences consisted of S.A.A.D. sentences and their passive, negative and passive negative equivalents, which could be either true or false descriptions of the pictures and could allow for either a non-anomalous or an anomalous reversal of the logical subject and object. Errors of judgement and reaction times were used as measures of complexity of processing. Slobin reported that even for the youngest children, who made the greatest number of errors of all the age groups, only 18.2% of all responses were erroneous. The pattern of errors showed the same general order of difficulty as the reaction times, which showed passives then negatives, then passive negatives, to be progressively more difficult than their S.A.A.D. equivalents. This order was observed for all age groups but was significant only for the 10 and 12 year olds and adults. Nor was this order observed for false or non-reversible sentences. Reaction times were quicker for non-reversable than reversible sentences. Non-reversability seemed to interact with passive sentences and Slobin suggests this was because it disambiguated the agent and patient terms independently of the word order. So while performance improved significantly with age and the same order of difficulty was observed for all age groups for true and reversible sentences, the evidence for a clear performative distinction between the different sentence types was not conclusive for the two youngest groups. Nonetheless Slobin (1966, p.277) concluded that "the grammatical system is already well developed by age six and that in order to find considerable age differences it would be necessary to work with still younger children."

That differences in the difficulty of processing active and passive sentences should be found only for true and reversible sentences received support from sentence-picture verification studies by Gluksberg et al (1973). Gluksberg's model of sentence verification by adults assumes that the presence of each constituent part of the sentence is checked against the picture before the way in which the constituents are related is checked. Thus, for non-reversible false sentences, whether active or passive, a mismatch between sentence and picture constituents would be discovered before the voice aspect of the sentence needed to be considered. However for true sentences and reversible false sentences Glucksberg claims that the same matching process results in more comparisons being necessary for passive sentences than for active ones. In order to make this claim Glucksberg has to assume that after the verb constituent the S will next try to check the grammatical subject of the sentence (the first mentioned noun) by searching for the constituent representing the agent in the picture. For true actives the picture-agent would correspond to grammatical subject and further comparisons would begin immediately. However for true passives the picture agent would not correspond to the grammatical subject and the S would have to continue to search for a picture corresponding to the grammatical object or second mentioned noun in the sentence.

This view of the verification process is flawed in several respects. If the S takes no account of the voice of the sentence until the end of the comparison process, but rather tries to match the grammatical subject to the picture-agent, then why is the comparison not terminated as soon as the mismatch is detected and a judgement of false given? If the S is assumed to be aware of the voice of the sentence which indicates that it is necessary to continue the comparisons, then why would the S seek to match the grammatical subject against the agent-picture? This need only be done if the S's first fixation happened to fall on the agent-picture. Even then it is difficult to see how the S would recognize the agent-picture as the agent until the whole array had been at least given some cursory scan. Since Glucksberg has made no attempt to control for this factor nor to incorporate into his model the implications of the visual search pattern of the S, his findings need to be reinterpreted so as to give a more thorough picture of sentence processing. Moreover when it comes to reversible false passive sentences, Glucksberg's account does not offer a very plausible explanation of how a subject might make a correct judgement if the voice aspect of the sentence is only checked at the end of the comparison process. This is because, for the reversible false passive sentence, the S who seeks to compare the first mentioned noun against the agent of the sentence will come up with a match and on proceeding with the comparisons will match all the constituents. Only if it is assumed that the S is aware of the voice constraint can he be expected to reverse the true judgement because of the way the constituents are related. But if the S was aware of the importance of the ordering, why would he have compared the grammatical asubject against the agent-picture in the first comparison.

One further situation for which Glucksberg et al found a voice difference occurred when the picture was presented to the subject before the sentence. Given that the subject knows the relevant aspect of the picture to represent, the model assumes that the subject will be predisposed to encode the picture in a verbal code and in the active voice. Thus it is only for active sentences that the orderings of the two representations will be congruent. However the model does allow that subjects may be induced to code the picture in a passive form if the picture representing the patient of the situation is seen to be the important aspect of the array. In this case the order incongruency of the two codings will occur for the active sentences as was found by Olson and Filby (1972).

Thus, on the whole, their model regards the surface structure of a sentence to be the important aspect of the sentence for most conditions under which sentences are verified. Whether this model has anything to offer for a developmental point of view requires further consideration in terms of whether a difference in active and passive sentence processing can be shown for young children and whether the difference can be attributed to the same factors as for adults.

Wright's (1969) results also suggest that difficulties with passives only arise where they are to be compared with representations that were not congruent in terms of surface structure order. She found that where a passive was to be compared with another passive or an active with another active, none of the confusion that arose in comparing an active with a passive was evident. In fact, passives compared with passives were even slightly easier than actives with actives, even though reversible sentences were used. These results cannot be explained by assuming that every passive sentence must be represented in a kernal form with a passive marker before it could be compared with any other representation. Wright also found that when asking questions about a sentence it was easier to answer questions about the logical subject than the logical object regardless of the voice of sentence and question.

Turner and Rommetveit (1967a and b) tried to establish just this but their results, which will be discussed shortly, still leave the nature of the sentence verification process in some doubt. They argued that the young child neither demonstrates a pragmatic need to emphasize an interest in the acted-upon element of a situation, when describing the situation linguistically himself, nor does he recognize a lack of emphasis on the agent in another speaker's description of a situation. To support this they cite Harwood (1953) who reported no passive sentences from Ss of age of 5 years 8 months. However Menyuk (1963) observed five out of 14 nursery school children using the passive form, while varying degrees of difficulty in comprehending and producing passive sentences were reported by Frazer, Bellugi and Brown (1963).

Turner and Rommetveit compared groups of children (mean ages 4.32, 5.37, 7.0, 8.11 and 9.0 years) on tasks requiring the imitation, comprehension and production of sentences which varied in voice and the semantic reversability of logical subject and object. By seven years there was virtually no difference between the various sentence types on the imitation task and even for the younger groups of subjects the differences were the smallest shown on any of the tasks. The production task showed even more significant differences distributed in the same manner as those shown in the comprehension task. Since it is a comprehension task used in the EM experiments, the performance of the children on this parti ular task will be considered more fully.

Turner and Rommetveit required their subjects to look at a picture in order to judge which of two sentences uttered by the experimenter was "the name going with the picture". Each sentence reversed the agent and patient relations expressed by the other without changing the voice. Half the pairs of sentences produced anomalous sentences when the agent and patient were reversed. For instance, the subject was presented with two sentences such as "The fly catches the frog" and "The frog catches the fly" or "The frog was caught by the fly" as opposed to "The fly was caught by the frog." The subject was then asked "Does the name "----" go with the picture?" and required to answer yes or no. The second sentence was presented in like manner. Although not stated explicity, one presumes that a correct reply required the subject not only to answer 'yes' to the appropriate sentence, but also 'no' to the inappropriate sentence.

The percentage of errors made in selecting the appropriate sentence was calculated for the different types of sentences pairs and taken as the measure of the difficulty of comprehending the different types of sentences. The results, as far as can be determined from the graphic form in which they were presented, seem to show a striking contrast with those of Slobin. As noted before, Slobin's six year old group made only 18.2% of errors over all sentences and the older groups made significantly fewer errors than this. Most of these errors were due to combinations of the factors of reversability, negation and passivity of voice. The percentage of errors (all figures are approximate) made by the group of mean age 5-8 years in the Turner and Rommetveit experiment was 75% for reversible passives, 60% for non-reversible passives, 25% for reversible actives and 10% for non-reversible actives. Even for the group with a mean age of 8.11 years, 25% errors were made on reversible passives and 10% on non-reversible passives.

Although the differences decrease with age, the groups with mean ages of 4.3, 5.8,and 7.0 years showed large differences between non-reversible active and passive sentences. This doesn't seem compatible with Slobin's findings that non-reversability washed out differences in reaction times to active and passives. So, not only is the overall error rate much greater for the four youngest groups than one would have expected from Slobin's results, but the reversability factor seems less important than the voice for sentence processing. Moreover Turner and Rommetveit's children had more opportunity to analyse the sentences, as each member of the pair being compared was presented twice. It is possible that the explicit rendering of the two sentences, varying only in word order, so confused subjects that they fell back on a strategy of choosing the sentence where the word order mentioned first the logical subject and then the logical object, ignoring the passive markers (is, -ed and by) or treating them as if they were signs of some uncommon tense. Since the 4.3 year group made 10-15% of errors even on non-reversible actives, it would seem that a certain amount of confusion existed even for the simplest sentences.

These discrepancies in results suggested that a re-examination of children's ability to comprehend active and passive sentences would be valuable. It was hoped that the measurement of eye movements as well as judgements and reaction times might provide a way of specifying the degree and nature of the differences in processing active and passive sentences for Ss of different ages.

5.3. Design: The experimental task was designed around the method used for recording the subject's eye movements. This method is described more fully in Chapter 2, but to briefly recapitulate it involved videotaping an enlarged image of one of the subject's eyes as the subject scanned a two-dimensional pictorial array. In order to score the video record it was necessary for the pictures making up the array to be sufficiently separated so as to require gross eye movements in order to scan the array.

Sentences: Because of the above consideration, it was necessary to construct transitive sentences which could not only take the active and passive voice but could also be appropriately evaluated against such arrays. The sentences had to refer to situations in which objects could reasonably be said to be related to other objects at a distance. Relationships such as 'chasing','following, 'watching', 'waving to', 'looking at', 'shooting' and 'running after' were used since even the youngest subjects were familiar with the situations referred to by these terms. Nearly all the logical subjects and objects of the sentences referred to pictures of animate objects, so as to make the sentences semantically reversible, since previous experiments have indicated that the effect of voice differences is most marked for reversible sentences. To give an example, the sentences took the form of either "The boy is chasing a dog" or "A dog is being chased by the boy".

Visual Arrays: The arrays were arranged in the same manner as those used on the EM studies reported in Chapter 4. In fact the ten arrays were drawn from the sixteen arrays used in Study 4.2. but they were selected so that the picture located at B position faced right on half the trials and left on half the trials.

Test Trials. The number of the test trials was restricted by the limited ability of the youngest subjects to sustain attention over any extended period of time, even when this period was broken by several rests. It was decided to present each subject with eight different visual arrays each described by both an active and passive voice sentence. Thus sixteen sentence-array combinations were constructed as the test items. These test items were divided into two groups of eight so that the eight arrays were all viewed once for each group of test items. These two groups were each comprised of trials which were balanced in terms of the voice of the sentence, the truth of the judgement and whether a left or right eye movement was required in order to search the array appropriately (see below).

Eight Arrays							
Four Active Sentences				Four Passive Sentences			
Two True		Two False		Two True		Two False	
1 Left	1 Right	1 Left	1 Right	1 Left	1 Right	1 Left	1 Right

Each combination of all these variables was represented by only one trial.

The first group of test items was labelled Group A and was ordered such that each voice-truth value combination was represented in the first pair and second four trials, while the appropriate eye movement direction was balanced. The second group of eight test items labelled Group B, was constructed by reversing the voice and truth value for each of the Group A items.

The eight subjects assigned to each age group were divided so that two subjects were presented with the 16 trials in each of the following orders:

1) Group A(1-4)-Group A(5-8)-Group B(1-4)-Group B(5-8)
2) Group A(5-8)-Group A(1-4)-Group B(5-8)-Group B(1-4)
3) Group B(1-4)-Group B(5-8)-Group A(1-4)-Group A(5-8)
4) Group B(5-8)-Group B(1-4)-Group A(5-8)-Group A(1-4)

One of the two subjects assigned each order of trials viewed all the arrays with the left eye and the other subject viewed with the right eye.

Another aspect of the design is that half the false items were of a binary nature. That is to say that the picture referred to by the logical object of the sentence was present in the array but not in the manner specified by the sentence. These items were included to investigate whether subjects would try to maintain the relationship specified by the sentence and thus focus on the inappropriacy of the logical object, or whether they would try to maintain the pictures referred to in the sentence and focus on the inappropriacy of the verb or logical subject.

An additional four arrays were also viewed by each subject at the end of both group of trials. The sentences to be judged required the subject to direct his initial eye movement to the non-faced side of the FFP. So in contrast to the first sixteen trials, these required the subject to look 'behind' the FFP in two-dimensional terms. In order to balance the design as far as possible, two of these sentences were active and two passive. one of each voice being true and one false. For each truth value one trial required a left FEM and one required a right FEM so that no combination of voice, truth value and side was repeated.

The sentence and arrays are listed in Appendix 5.1.

5.4. Subjects: Subjects were selected in the manner described in Chapter 2.3. Subjects were divided into four age groups with the following mean and median ages, and range of ages, given in years and months.

	Mean Age	Median Age	Range of Ages
Group 1	4.11	5.0	4.8 - 5.1
Group 2	7.6	7.8	6.0 - 10.2
Group 3	14.5	14.1	12.11 - 17.4
Group 4	25.3	25.0	22.0 - 28.0

Each group consisted of four males and four females except for Group 3 which contained six females and two males.

5.5. Procedure. Two procedural differences from the description given in 2.3 are to be noted. For the second group of sentences to be judged the initial identification of the picture to be the logical subject in the test sentence was dispensed with. The experimenter introduced the picture into the box and said "see the....".

Also the test sentence was uttered for the first time while the picture referred to by the logical subject remained at the B position after its identification. This was to give the subject every opportunity to encode the orientation of the picture and its relevance for the picture. Two further utterances of the test sentences were made while the lights were extinguished.

All subjects used the right hand to signal 'right' with the bell button and the left hand to signal 'wrong' with the buzzer button.

In the pre-testing situation while they were labelling the pictures the youngest children were asked to "make it so x-picture is following y-picture". This was to ensure that the child understood the word which was the only one to give the G1 Ss some difficulty. Where it did prove difficult, the word "chase" was substituted in the appropriate places in the test sentences.

5.6. Scoring: The judgements and RTs were taken, the No.EMs calculated and the EM Patterns scored for each test trial. Additionally the No.EMs made between adjacent pictures

(A and B, B and C) and between non-adjacent pictures (A and C) were noted.

Reasons for all test trials were scored with respect to their abbreviated or unabbreviated form, their affirmative or negative form, their appropriacy and the voice of the unabbreviated statements. An appropriate reason was taken as one where the subject mentioned that part of the sentence which didn't correspond to the array or the absence of the part of the array expected to be present if the sentence was true. For instance, if the sentence "the boy is chasing a dog" was false of an array because the boy was chasing a girl, an appropriate reason could specify the mismatch in a variety of forms such as, "the boy is chasing a girl" or "The boy is not chasing a dog" or the passive form of these sentences. The abbreviated form of these statements such as "a girl" or "not a boy" or a combination of the negative and affirmative forms were acceptable. Where the subject denied the relationship between the pictures, this was noted. An inappropriate reason was one that did not specify the relevant mismatch but was concerned either with the presence of the irrelevant picture or mentioned an irrelevant relationship pertaining to the array or mentioned a relationship totally irrelevant to the situation such as "little boys shouldn't chase dogs". The appropriacy of the reason was scored as ambiguous when the subject did not specify the mismatch but listed the pictures in the array or the full set of relationships existing between them.

5.7. Analyses of Various Measures of Performance

Judgements: Incorrect judgements were analysed as to whether they occurred on active or passive, true or false test items.

Reasons: The voice and the affirmative or negative form of all the reasons were analysed according to the voice of the test sentence. This analysis and the frequency of occurrence of the various classifications were compared across the age groups for all test items.

Eye Movements to Adjacent and Non-Adjacent Locations: The frequencies of eye movements made to adjacent and non-adjacent locations were compared across the age groups for all test items.

RTs, No.EMs, AFEMs and EM Patterns: For the sixteen 'faced' trials the RT and EM measures were analysed by means of a Five-way Analysis of Variance with repeated measures on four factors in order to ascertain the effect on performance of age of the S, the truth value and voice of the sentences, the side of the array where the relevant picture was located and the order of presentation of the trials. For the same trials the AFEM and EM Pattern measures were analysed to examine the effects of the same factors by means of a Five-way and Six-way Partitioning of Chi-square respectively for the two measures. The additional factor was that of Patterns.

For the 'faced' trials the RT and No.EM measures were further analysed for those trials on which AFEMs were made and the mean scores compared to those obtained from trials on which IFEMs were made.

The percentage of AFEMs made by Ss viewing with either their left or their right eye were ascertained for trials requiring a left of right FEM.

The false 'faced' trials were examined separately by means of a Four-way Analysis of Variance with repeated measures on three factors for each of the RT and No.EM measures, and by means of a Four-way and Five-way Partitioning of Chi-square for the AFEM and EM Patterns respectively. The factors of age, voice, side and the binary or non-binary nature of the false sentences were examined.

The four 'behind' trials were examined in terms of the AFEM and EM Pattern measures to see if the factors of age, voice and truth value affected the performance on these trials. The mean percentage of AFEMs made on these trials was compared with that obtained on four comparable 'faced' trials.

Individual comparisons following on any significant overall results were made by means of the Tukey test for RT and No.EM measures and the Kolmogorov-Smirnov Two-Sample test and the Wilcoxin Matched-Pairs Test for the AFEM and EM Pattern Measures.

5.8. <u>Hypotheses</u>: This section will attempt to spell out in detail the various patterns of results that would be expected either on the basis of previous findings on related topics or on the basis of alternative models of sentence/picture comparisons. By comparing the degree to which the results accord with the different hypotheses it is hoped to determine which factors cause the measures of performance to deviate in particular ways from those possible for the most efficient method of performance.

The most efficient way in which to evaluate the sentences being tested was to utilize the relevant spatial cues provided by the FFP which represented the logical subject of the sentence. This would enable the viewer to locate the logical object of sentence and to verify that the logical object and verb were valid descriptions of the picture. For instance if the sentence 'the boy is chasing a dog' was to be evaluated against an array consisting of a dog, a boy and a lion in the C, B and A positions respectively with the dog and the boy both facing left, then the most efficient strategy would be to look left from the initially fixated 'boy' to identify the picture of the dog in C position and to make and signal a decision about the sentence. If the boy was facing right then it would be necessary to first scan to the A location to the right of the boy.

5.8.1. Reasons. It was expected on the basis of previous findings, that reasons would be given in the passive voice only when passive sentences were to be verified and their frequency of occurrence would increase with the increasing age of the groups of subjects. It was also expected that the younger the subject the more likely he would be to give an inappropriate reason.

5.8.2. Eye Movements to Adjacent and Non-adjacent Pictures
It was expected that of those subjects who attended to some extent to the irrelevant picture the younger the subjects the more eye movements would be made between adjacent than

non-adjacent pictures. This was because it was thought the older the subject the more able he would be in retaining the identity of the middle picture without fixating it and the greater ability he would have in overriding perceptual constraints of fixating the nearest stimulus. The older the subject the more able he would be in directing his EMs according to his own cognitive demands.

5.8.3. Order of Presentation of Test Trials. If the subject developed a strategy for dealing with the task during the course of the experiment it was expected that there would be an overall improvement in the subject's performance during the second group of trials, evidenced by shorter RTs, a reduction in the number of EMs and an increase in the number of AFEMs. However since the arrays were each viewed twice it was possible that in the second group the subject was carrying out a search on the basis of his memory of the array associated with each logical subject and sentence. If such was the case, then improvement would be expected particularly on those second test trials where the sentence was a true description of a previously seen array. Even if this was the case it was expected that any differences on active/passive and left/right comparisons would be maintained though possibly reduced in the second group of test trials. This is because there were an equal number of the various kinds of false sentences which became true on the second presentation. Moreover, though possible it was unlikely that subjects were basing their search on their recall of the arrays, since if they could remember the array they might have been able to make a judgement without even scanning the array.

5.8.4. Age Differences. It was expected that there would be a general improvement in the performance of the subjects with increasing age. This would mean a reduction in verification times and the number of EMs due to factors such as an increase in speed of verification processing, memory capacity and possibly ocular-motor as well as motor skills.

5.8.3. Developmental Differences in the Amount of Attention Paid to Irrelevant Information. For the reasons discussed in Chapter 2.5.3, it was expected that the younger the subject the more distracted he would be by the irrelevant stimulus. This would result in differences in the frequency of the various eye movement patterns occurring for the different age groups. Young children would be expected to make more searches of an inefficient nature and older subjects more searches of an efficient nature. It was expected that only the older subjects would be sufficiently de-centered to direct their gaze from one significant part of the array to another and to attend only to the relevant aspects. This would provide a partial explanation of any decrease found in the No.EMs made by older subjects although other factors such as fewer memory limitations may also contribute to the reduction.

5.8.6. The Influence of Perceptual Factors on Task Performance If the subjects were able to direct their search in accordance to the cognitive demands of the task, then no difference would be expected between the number of AFEMs made on 'left' and 'right' trials.

If the subject relied upon being guided by perceptual factors such as information from the periphery of the retina about the location of picture referred to by the logical object of the sentence, then such information would appropriately guide his FEM for true trials, inappropriately guide his search for binary false trials and provide no information on non-binary false trials. Thus one would expect more AFEMs to be made on true trials than on non-binary trials and fewest of all to be made on binary trials. Other perceptual biases influencing the processing of information from different parts of the periphery were also determined. Two such biases were firstly, the extent of the visual field for the right and left eyes, the right eye favouring the location of objects falling in the right visual field while the reverse is true of the left eye, and secondly, the fact that for the right and the left eye, images of pictures from the left and right side of the array respectively probably fell partially on the blind spot. If these factors were operating in guiding the searches of the subjects then for right-eyed subjects few AFEMs would be made on trials requiring a left EM while for left-eyed viewers few AFEMs would be made on trials requiring a right EM. This might also influence the subject's behaviour on non-binary trials in the same way, while for binary trials even more inappropriate FEMs would be made by right-eyed subjects on 'right' trials and by left-eyed subjects on 'left' trials. No findings were sought nor conclusions drawn about any left or right visual field effects due to asymmetries in lateral cerebral functioning.

Since children are generally held to be more dominated by perceptual than conceptual events, it was expected that perceptual factors might influence their performance more than that of older children and adults.

If the subject neither operated under cognitive nor perceptual constraints then it was assumed that individual ocular-motor habits or various uncontrolled subtle perceptual effects were operating.

5.8.7. The Influence of Truth Value on Task Performance. Gough (1965, 1966) found there was no interaction of voice and truth value when active and passive sentences were being verififed. Active sentences took less time than passives and true sentences less time than false. Both Clark (1970, 1972) and Trabasso's (1970, 1971) models would also predict that for actives the true sentences will take less time to verify than false since less time is spent in detecting mismatches and in changing the truth index which is initially set at true. However predictions about the relative difficulty of true and false passive sentences vary depending upon whether normal processing is assumed to approximate models such as those suggested by both Clark and Trabasso's 'true' or 'conversion' models.

In the 'true' model the subject, object and verb features of the sentence coding are compared directly against the picture coding. The truth index is changed to false if there are any mismatches and further adjustments of the index will occur if the two codings are differentially signed for voice. This model leads to the prediction that false passives will be easier than true passives.

The 'conversion' model, which assumes that passives are translated and coded into their equivalent active forms leads to the prediction that true passives are easier than false passives. Evidence from various studies supports the view that the 'conversion' model is most appropriate description of subject's processing. However for Slobin's (1966) results, the 'true' model accounts best for the children's performance in verifying active and passive sentences.

Neither of these models would predict any differences in the number of fixations made in forming the picture coding. Both models assume that the subject would terminate his search after forming an active coding. Differences in the verification times would result from differences at the comparison stage.

Glucksberg etal (1973) propose that sentences and pictures need not be given a full abstract representation, nor need these representations be fully compared. Features of the sentence are checked against the picture and the search terminated as soon as a mismatch is found. Thus in the present study true judgements would be expected to take longer than false judgements since all the features as well as voice information must be checked. False trials would also be predicted to require fewer eye movements since search would terminate upon the location of the falsifying feature of the sentence.

Provided that information from the retinal periphery was not being used to guide search, it was expected that true and false trials would elicit an equal number of AFEMs. If information from the periphery was used to guide EMs then as suggested in the previous section, true trials would receive more AFEMs than non-binary false trials and in turn both would receive more than binary false items.

5.8.8. The Influence of Sentence Voice on Task Performance.

1) Differences Resulting from an Agent-Verb-Patient Interpretation of All Noun-Verb-Noun Sequences.

If, as suggested by Bever (1970) and Turner and Rommelveit (1967a), young children tend to interpret all noun-verb-noun sequences as corresponding to an agent-verb-patient description of a situation, then one would expect the comprehension of passive sentences by the youngest subjects to be extremely poor. This poor comprehension would be manifested by certain patterns of judgements and reasons for those judgements.

These patterns can be illustrated by considering the following instance of the sentence "a dog is being chased by the boy" which is true of an array consisting of a picture of a boy at B position, a dog at C and a lion at A, with the boy, dog and lion all facing left. If the subject interpreted the sentence in the same manner as for an active, then it would be judged false for some reason such as "The lion is chasing the boy" or "The dog is not chasing a boy".

If the same passive sentence is false in a binary fashion because the dog picture occupies the A location and the lion the left location, then the subject interpreting the sentence as "the dog is chasing a boy" would judge it as true of the array.

If the passive sentence is false in a non-binary fashion because a duck is being chased by the boy, while a lion is in the A position, then the subject will judge the sentence false whether or not he interprets it in the appropriate way. However if a passive interpretation was made, then the reason would be of the nature "because the boy's chasing a duck" or "Because the boy's not chasing a dog". If an active interpretation is made then the reason will be of the nature "there's no dog chasing the boy" or "the lion's chasing the boy".

So, by determining how often inappropriate judgements and reasons were given to the various test trials it was hoped to establish whether the young subjects had difficulty in comprehending passives for such reasons as, because they processed them as actives or because they transformed them into their active equivalents with passive markers but forgot the passive marker.

ii) Differences Resulting from Different Transformational Histories of Active and Passive Sentences.

If, as Miller (1962) suggests, the subject is able to comprehend passives only by deriving their transformational history to the kernal form plus a passive marker, then no differences would be expected between the number of correct judgements for actives and passives in the present experiment. This is because, like Gough (1966), sufficient time was provided for the subject to derive the kernal forms of the passives before the actual verification process began.

iii) <u>Differences Resulting from Mismatches Occurring During the Comparison Stage of the Verification Process</u>.

Wright (1969) showed that sentences are only difficult to compare when a difference in voice makes some sort of transformation necessary before they can be directly compared. Clark (in press) argues that the same sort of mismatch occurs during the comparison of the abstract representations of a passive sentence and a picture. This is because for humans the agent is most often the salient aspect of a situation so that pictures are usually encoded into an active form. Thus where sentences are compared against pictures which can be freely encoded the abstract representations of both will only have the same format for actives.

Assuming that subjects do attempt to compare representations for the sentence and picture, the idea of a 'mismatch' has some application for the eye movement study since the picture referred to by the logical subject of the sentence was always the first fixated. Thus subjects were possibly even more constrained than normal to code the picture into an active abstract representation. With passive sentences additional transformations or operations would be necessary in order to compare the two representations, resulting in longer RTs. No differences would be expected in the No.EMs made in scanning the arrays so as to construct the representation, since in both cases the same active representation is assumed to be constructed.

However it is necessary at this point to recall Donaldson's stricture that an appropriate representation of the picture, be it in active or passive form, can only be constructed by using the sentence to select the relevant aspects of the picture to encode. Taking the same example as before, if the 'boy, dog and lion' array was encoded independently of the sentence to be verified, then it could be coded as either 'the boy is chasing a dog' or 'the lion is chasing the boy' or even 'the three pictures are all living things'. The chances would be small of having a representation which could even begin to be appropriately compared with the sentence representation.

However, the idea of a mismatch can still be applied if it is allowed that subjects may attempt to directly check the sentence in its surface structure form against the array, or as Donaldson would phrase it, if the subject interrogates the picture according to the questions formed on the basis of the sentences to be verifiifed. For active sentences the first term or feature of the sentence matches the FFP, as does the verb, and the sentence can be used to direct the FEM to locate and check the second term of the sentence, which is the logical object, against the picture to which it refers. However for passives the FFP is the second mentioned term or the grammatical object of the sentence and would not be checked until after the first mentioned term of the sentence is located and checked. Thus even if the subject comprehended the passive sentence and its implication for search, the structure of the sentence would impose a search strategy which would take longer to complete for passives. Differences in RTs and the number of EMs would be expected between active and passive sentences.

Glucksberg et al's (1973) model of sentence/picture verification processes provides an even more complex set of hypotheses, given the structure of the experimental task. To recapitulate briefly, they argued that sentences and pictures need not be fully encoded in an abstract way, nor was there always a need for them to be fully compared. Rather the sentence, regardless of its voice, would be checked by checking first the verb, then the grammatical subject then the grammatical object. A final checking of voice information would only be necessary for true sentences and binary false passives.

Now, since the logical object was always the falsifying feature of the sentence in the present study this formulation has the following implications. Firstly, differences between true and false actives would be smaller than differences between true and false passives. This is because for actives the logical object is the grammatical object and would be the last to be checked after the verb and grammatical subject. Thus false judgements would take nearly as long as true judgements where only additional voice information needs to be dealt with. But for passive sentences the logical object was the grammatical subject which would be the first to be checked (according to

Gluscksberg) and thus a false judgement would be made far more quickly than a true one where all the other constituents would still have to be checked. On this count one would expect longer RTs and a larger number of EMs for false actives than for false passives.

The second implication of the formulation is that since the subject always began by fixating the picture referred to by the logical subject, then with true actives, he can start verifying the sentence on the first fixation whereas for the passive sentences the subject must first locate the grammatical subject before the verification process can begin. Thus the true passives will take more time and eye movements to verify than true actives.

The overall order of difficulty predicted by this model is, from easiest to most difficult: FP $<$ FA $<$ TA $<$ TP.

iv) <u>Differences Resulting from the Semantic Role of the Picture to be Located</u>

Another approach which may have some relevance for the present experiment is that of Huttenlocher. Huttenlocher (1968) found that when children from 5-7 years had to place a specified object with respect to a second fixed object according to verbal instructions, then it was easier to do so if the object to be manipulated was described by the logical subject of the instruction sentence. This was true whether the instruction sentence was in the 'active' or 'passive' voice. However further experiments by Huttenlocher and Weiner (1971), which varied the number of objects to be manipulated according to active or passive instructions, revealed a rather more complex pattern of results. In the situation most analogous to the experimental EM task subjects had to select one of two objects to place relative to the remaining object. In this case subjects were more likely to move the logical actor for both active and passive instructions, although it was even more likely to be chosen when active instructions were given. In those situations where the subject was required to move both objects, then word order accounted for the order of moves. Wright reports a similar finding inasmuch as she found that questions asked about the logical subject of a sentence were easier to answer regardless of the voice of the sentence or the question.

Now considering the active/passive EM study in terms of these studies, the first fixated picture which was the logical subject could be regarded as the fixed reference object and the logical object as the 'mobile' object, since it is the one to be placed or located with reference to the 'fixed' logical subject. Since the logical object was always the 'mobile' object for both active and passive sentences this analysis would not anticipate any differences in terms of RTs, EMs or AFEMs in the ability of subjects to locate the logical object.

Taking this view of the task does not however specify how the passive sentence is processed so as to ascertain which constituent is the logical subject and which the logical object. Nor does the analysis have anything to say about differences in dealing with true and false sentences.

On the basis of this analysis of the task one would only expect to find differences between actives and passives, if the logical subject was first fixated for the actives and the logical object first fixated for passives or vice versa. Thus a difference will only result from a situation where the first fixated picture has a different semantic or logical role in the active and passive sentences. This study looked at the difficulty of verifying sentences under two conditions: firstly, when the first fixated picture was referred to by the logical subject of the sentence and secondly, where the first fixated picture was referred to by the logical object of the sentence. The first fixated picture was never the aspect of the array which falsified the sentence.

5.9. Results. The performance of the subjects on each of the measures will be discussed first and then a summary will be given of the type of performance given by subjects of each age group. In the tables which summarize the results the test scores and levels of significance have been given where relevant. However F values have been omitted where they fall below the value of one.

Throughout the tables the following abbreviations have been used: active (A) and passive (P) sentences, true (T) and false (F) sentences, left (L) and right (R) side, Groups 1, 2, 3 and 4 (G1, G2, G3, G4) and first (1st) and second (2nd) order of presentation of trials.

5.9.1. Judgements and Reasons. Most subjects were able to give correct judgements of active and passive sentences.

Ss from Groups 3 and 4 made no errors, while over all trials Ss from Group 1 made four inappropriate judgements of actives and four inappropriate judgements of passives and Group 2 Ss made three inappropriate judgements of passive sentences. The eight errors made by Group 1 Ss were made by five Ss, three of whom made an error on one active and one passive sentence, one of whom made an error on an active sentence and one of whom made an error on a passive sentence. The errors were equally distributed across true and false trials for both active and passive sentences. As clarified by the reasons, only two of these errors were obviously due to a misinterpretation of the sentence. One sentence was judged inappropriately because the child denied the appropriacy of the description of the action, because to him the dog looked as though it was 'lying down' and not 'running'. The remaining two errors were so judged because of the presence of the irrelevant picture. Two of the three errors made by Group 2 were made by one S. One error by each S was due to a misinterpretation of the sentence as can be seen when one S said 'a lion is being followed by the girl' was wrong "because there's a butterfly following the girl", and the other S judged 'a horse is being pulled by the engine' as wrong because "the car's pulling the engine and the engine's pulling the horse." The reason given for the third erroneous judgement was given in terms of the presence of the irrelevant picture, "because there's a duck there too". For Group 2 Ss all the errors were made on true trials. Several of the errors occurred on the sentence describing a "pulling" relationship where the three-pictures in the array were linked by drawing a thick line between them so as to represent a rope. The Ss found it especially difficult to disregard the irrelevant picture in this situation.

From Table 5.1 it is clear that, of those reasons which could be classified according to voice, all except one of the reasons elicited by the active sentences were in the active voice. For Groups 1, 2 and 3 the majority of reasons elicited by passive sentences were also in the active voice. Only Group 4 subjects gave a majority of their reasons for false passive sentences in the passive voice. However Groups 1 and 2 did give substantially more 'passive' reasons to passive sentences than to active sentences.

TABLE 5.1.

Percentages of Reasons Given in the Active and the Passive Voice to Active and Passive Sentences for the Four Age Groups.

Voice of Sentences	Active		Passive	
Voice of Reasons	Active	Passive	Active	Passive
Groups				
1	100%		77.8%	22.2%
2	100%		70.6%	29.4%
3	100%		96.3%	3.7%
4	96.7%	3.3%	25.8%	74.2%

With some of the older subjects it sometimes proved difficult to elicit reasons for false judgements, the subjects being reluctant to give what seemed to be obvious answers. However a sufficient number of reasons were given to provide a reasonable comparison between the groups. Of the reasons given a certain number were excluded from analyses. These included ambiguous and inappropriate reasons where the inappropriate aspect of the array was described or a totally irrelevant comment was made or all the relationships or objects in the array were described. An inspection of the numbers involved, which are given below in Table 5.2, shows that only the youngest subjects gave any number of inappropriate or ambiguous reasons.

TABLE 5.2

Numbers of Appropriate (A) and Inappropriate (IA) and Ambiguous (Am) Reasons given by Groups 1,2,3 & 4

Groups	A	IA + Am	Total No. of Reasons
1	64	15	79
2	69	5	74
3	69	3	72
4	67	2	69

Considering only the appropriate reasons whether they were given in abbreviated or complete sentences, there was a general increase with age in the use of a negative form either alone or together with an affirmative statement. Group 2 subjects did not conform to this pattern as can be seen from Table 5.3.

TABLE 5.3.

Percentages of Reasons given in Affirmative (A), Negative (N) or Affirmative and Negative (A&N) forms.

Groups	Form of Reason A	N	A&N
1	87.5%	10.9%	1.6%
2	97.1%	-	2.9%
3	78.3%	13.0%	8.7%
4	77.6%	10.4%	12.0%

5.9.2. Eye Movements to Adjacent and Non-adjacent Picture Locations and to Additional Locations.

The results are summarized in Table 5.4.

TABLE 5.4.

Percentages and Frequencies (given in brackets) of EMs made by Groups 1, 2, 3 and 4 to Adjacent (AP) and Non-adjacent (NAP) Pictures and to Additional Locations (AL) Excluding those Trials on which an Efficient Search was Made.

Groups	Total No EMs made	AP	NAP	AL
1	571	68.7 (392)	25.6 (146)	5.8 (33)
2	347	63.7 (221)	34.3 (119)	2.0 (7)
3	244	59.0 (144)	40.6 (99)	0.4 (1)
4	221	80.5 (178)	19.5 (43)	- -

With regard to EMs made to additional locations (AL) other than those specified by the presence of a picture, it can be seen that there is an inverse relationship between fixations on non-pictorial areas of the visual field and increasing age. However, even for Group 1 subjects only 5.8% of all their EMs were made to locations that were not marked by a picture. Thus it would seem that by four to five years children were able to more or less successfully direct their EMs to the approximate area of locations that would provide some pictorial information, be it relevant or irrelevant to the task at hand. Seen in another light, the results show that even the youngest subjects were able to quickly habituate to most of the aspects of the experimental situation which remained constant over a number of trials, such as the lights and inside the box.

The results for Groups 1, 2 and 3 reveal a pattern whereby with increasing age fewer EMs were made between adjacent pictures (AP) and more EMs were made between non-adjacent pictures (NAP). This means that the older subjects were more able to ignore the picture at position B with which they were familiar and which never falsified the sentence, even though it fell along the path of any EM made between pictures at locations A and C. It is difficult to determine whether the younger subjects referred more often to position B because they were less able to remember the identity of the picture or because they were less able to direct their EMs in accordance with information from the more distant of two stimuli.

A greater percentage of adults' EMs were between adjacent locations than for any of the other three groups. The only way to explain this anomaly is to suggest that because adults made more efficient searches which involved more than one eye movement than teenagers, this necessarily increased the number of EMs made by adults between adjacent locations. If one considers only those trials on which adults made inefficient searches (See Table 5.5) then the percentage of EMs made to AL pictures is more greatly reduced for the adults than for any other group. Even so the adults made slightly more EMs to AP than even Group 1 subjects. It may be that it is only after the relevance of the B picture has been established that it can be literally 'overlooked'. This may take a certain number of EMs. Since adult subjects make fewer EMs than any other group it is likely that most of the EMs that they do make will be between adjacent pictures while making a cursory examination of the array. It would seem that those subjects who do not terminate their search at this point are more likely to make their additional EMs between non-adjacent pictures.

TABLE 5.5

Percentages and Frequencies (given in brackets) of EMs made to Adjacent and Non-Adjacent Pictures. (APs and NAPs) for All Inefficient Search Trials for Groups 1, 2, 3 & 4.

Groups	Total No. EMs for Inefficient Searches	AP	NAP	AL
1	524	66.0 (346)	27.9 (146)	6.1 (32)
2	309	60.5 (187)	38.5 (119)	1.0 (3)
3	204	51.5 (105)	48.5 (99)	- -
4	141	69.5 (98)	30.5 (43)	- -

5.9.3. Results for "Faced" Trials. The results for the "faced" trials will be discussed in terms of the factors found to affect various aspects of the S's performance as measured by RTs, Number of EMs, AFEMs and the Kinds of Patterns made. Then the effect of the binary/non-binary nature of the false trials will be examined. Finally the factors affecting the AFEM and Pattern measures taken on "behind" trials were considered.

RT Results for "Faced" Trials: These results have been summarized in Table 5.6, from which it can be seen that the

TABLE 5.6.

Factors Affecting RT Measure for "Faced" Trials

Comparisons	F Value	df	Level of Sig.	Mean Scores				
Age (G1,2,3,4)	29.95	3/28	.001	4.28 v 2.37 v 1.45 v 1.72				
Voice (A v P)	19.71	1/28	.001	2.29 v 2.63				
TV (T v F)	40.33	1/28	.001	2.25 v 2.66				
Side (L v R)	-	1/28	NS	2.43 v 2.48				
Presentation Order (1st v 2nd)	-	1/28	NS	2.45 v 2.46				
Order x Age	5.22	3/28	.01		G1	G2	G3	G4
				1st	3.96	2.54	1.51	1.81
				2nd	4.61	2.21	1.38	1.63
Order x Age x TV	5.40	3/28	.01	1st				
				T	3.87	2.20	1.39	1.72
				F	4.05	2.88	1.64	1.89
				2nd				
				T	3.98	2.09	1.32	1.47
				F	5.24	2.33	1.44	1.79
Age x Voice	3.27	3/28	.05	A	3.91	2.21	1.39	1.62
				P	4.65	2.54	1.50	1.82
Age x TV	3.58	3/28	.05	T	3.92	2.14	1.35	1.59
				F	4.64	2.60	1.54	1.85

age of the subjects as well as the voice and truth value of the sentences were all found to affect the time taken to judge the sentences. Neither the physical location of the picture (left or right) nor the presentation order of the trials were found to have any significant influence when considered over all Ss and trials. Age was found to interact with each of the factors of Voice, Truth Value and Presentation Order and to interact with both the Order and Truth Value Factors. The significance of the Voice and Truth Value Factors indicated that passive sentences took longer to judge than actives and false judgements took longer to make than true judgements.

The effect of the Age Factor was such that Group 1 Ss took significantly ($p=.02$) longer to make a decision than Group 2 Ss, and significantly ($p=.001$) longer than both Group 3 and Group 4 Ss. No significant differences were found between Groups 2 and 3, Groups 3 and 4, and Groups 2 and 4, although Groups 3 and 4 took less time to make a decision than did Group 2 Ss. As well as taking longer than any other group to make a decision, Group 1 Ss showed a significantly ($p=.01$) greater difference between RTs for true and false sentences than did the other groups, with true sentences taking less time to judge than the false ones. This group also showed a significantly ($p=.05$) greater difference between RTs for active and passive sentences than did the other groups. This group also showed a significantly ($p=.05$) greater difference between RTs for sentences presented first and second compared to the other groups, with more time being taken to judge sentences presented a second time than those presented first. For the three older groups the trials presented second were judged slightly faster than those presented first. Effects of fatigue or interference might be used to explain this interaction but it is unclear how such effects would operate selectively so as to also account for the significant three-way interaction effect whereby false trials took significantly longer to judge when presented second than when presented first, whereas true trials were not affected by presentation order.

<u>No. EMs Results for "Faced" Trials</u>: These results have been summarized in Table 5.7. As was found for the RT measures the factors of Age, Voice and Truth Value all proved to have a significant effect on the S's performance in the same way as was found for the RT measure. Again the effect of the location or Side of the array of the relevant picture had no significant effect but the effect of Order of Presentation was significant with fewer EMs being made on the trials presented second.

The effect of Truth Value interacted with that of Voice, with a significant (p=.01) smaller difference in EMs occurring between passive true and false trials than occurred between active true and false trials, where more EMs were made on false than on true trials. The effect of Truth Value also interacted with that of Side so that the difference between the EMs made on true and false trials requiring a right FEM was significantly (p=.05) greater than the difference between true and false trials when a left FEM was

TABLE 5.7.

Factors Affecting the No.EMs Measure for "Faced" Trials

Comparison	F Value	df	Level of Sig.	Mean Scores
Age (G1,2,3,4)	32.1	3/28	.001	4.57 v 3.03 v 2.27 v 2.29
Voice (A v P)	17.7	1/28	.001	2.83 v 3.25
TV (T v F)	32.1	1/28	.001	2.76 v 3.32
TV x Voice	8.99	1/28	.01	T F A 2.41 3.25 P 3.12 3.38
Side (L v R)	-		NS	2.98 v 3.10
Side x TV	5.61	1/28	.05	T 2.84 v 2.69 F 3.12 v 3.51
Presen- tation Order (1st v 2nd)	6.93	1/28	.05	3.19 v 2.89
Age x TV x Order	5.77	3/28	.05	1st G1 G2 G3 G4 T 4.56 2.72 2.28 2.41 F 4.46 3.78 2.59 2.71 2nd T 3.97 2.50 1.91 1.78 F 5.28 3.12 2.31 2.25

required. This was because more EMs were made on false than true trials when a right EM was required and usually made, while for left FEMs it was easier to inhibit EMs whether or not a true or false judgement was to be made. Lesévre (1966) argued that right lateralization of gaze, that is, the easier performance of ocular movements towards the right, does not exist at the age of six years but establishes itself between the ages of seven and eight years and continues to increase slightly until adulthood. Accordingly it should be the case that more EMs are made on left trials because if a left FEM is made the only pictures available for inspection are situated to the right. But the opposite was found and the only suggestion that can be put forward is that the pictures lying to the left from positions B and C were particularly attractive in some uncontrolled way. These pictures would have thus held the Ss gaze when he looked to the left and attracted the gaze when the S looked to the right.

As with the RT measure, the effect of Age interacted significantly with that of Truth Value and Order. This reflected the fact that for Group 1 Ss on the trials presented second and for Group 2 Ss on the trials present both first and second, the false trials elected significantly (p=.01, .001 and .02 respectively) more EMs than did the true trials whereas for Groups 2 and 3 the differences between true and false trials were not significant for either the first or second presented trials. For the first presented trials given to Group 1 Ss slightly more EMs were made on true than on false trials. It would seem that Group 1 Ss take some time even to recognize what constitutes relevant information for a true judgement whereas Group 2 Ss were able to act upon the information relevant for a true judgement from the very beginning. Neither group were as good at recognizing what information was relevant for a false judgement even after some practice. Group 3 and 4 Ss however, were able to use the same information as verifying or falsifying with more or less equal facility without requiring any practice.

AFEM Measure Results for "Faced" Trials: None of the factors found to affect the other measures had a significant effect on the number of AFEMs made, as can be seen by reference to Table 5.8.

TABLE 5.8

Factors Affecting the AFEM Measure for "Faced" Trials.

Comparison	χ^2 Value	df	Level of Sig.	Mean Scores
Age (G1,2,3,4)	4.84	3	NS	11.37 v 11.62 v 12.87 v 14.87
Voice (A v P)	0.25	1	NS	12.37 v 13.00
TV (T v F)	1.16	1	NS	13.50 v 11.87
Side (L v R)	0.35	1	NS	13.06 v 12.31
Order (1st v 2nd)	0.26	1	NS	12.48 v 13.04

The fact that Truth Value did not have a significant effect meant that the presence of the mentioned LO in the array did not help the S to direct his FEMs more appropriately on true than on false trials. Nor did the passive sentences disrupt the ability of Ss of any group to look in the "faced" direction, which is interesting inasmuch as on passive trials the FFP was not the picture first mentioned in the sentence. Either the Ss had decoded the passives into their equivalent active forms and used the active form to direct their FEMs thus being equally proficient at both, or else the S's strategy whenever trying to verify a relationship was to look in the faced direction of the FFP no matter what the sentence. This latter suggestion seems more likely when the differences between actives and passives in terms of other measures is considered and is lent weight by the results of the "behind" trials which will be dealt with later.

Of all the experimental variables age proved to be the most influential, even though the level of significance only reached $p= 0.2$. There was some increasing ability to make AFEMs with age, but even the youngest Ss were fairly proficient at directing their FEMs in the faced direction as had been found in the study using only active sentences.

It is relevant at this point to note that the ability of subjects to make AFEMs is related to their ability to verify the sentence efficiently in other respects. It is apparent from Table 5.9 that for all groups more EMs were made and a longer time taken to judge a sentence when an IFEM was made. This may have been due to the IFEM itself, since when an IFEM was made the subject had of necessity to make at least one more EM to find the relevant picture which entailed additional time being taken. This explanation however is not completely satisfactory since subjects, especially those from Groups 1 and 2, made unnecessary EMs even on trials with AFEMs. Thus an IFEM did not allow subjects to immediately treat that information as irrelevant. The relevant information had first to be found and then the irrelevant information established in terms of that.

TABLE 5.9.

Mean No.EMs and Mean RTs (in seconds) on 'Faced' Trials where the FEM was Appropriate and Inappropriate. The Numbers of Trials from which Mean Scores were Derived Are Given in Brackets.

No.EMs	'Faced' Trials			
	AFEM		IFEM	
G1	4.35	(91)	5.11	(37)
G2	2.93	(94)	3.83	(34)
G3	2.19	(103)	2.68	(25)
G4	2.33	(120)	4.38	(8)
RTs				
G1	4.08	(91)	4.48	(37)
G2	2.47	(94)	2.82	(34)
G3	1.43	(103)	1.71	(25)
G4	1.70	(120)	2.06	(8)

One further point will be discussed with respect to the AFEM measure. This concerns whether there was any effect of one picture in each array falling on or near the blind spot of the viewing eye. The percentages of AFEMs made by Ss viewing with their left eye were compared to those of Ss viewing with their right eye for both trials requiring left and right FEMs. The percentages are given in Table 5.10.

As can be seen, except for Group 3 Ss, there was no tendency for right-eyed viewers to look left more appropriately than they looked right which is what would be expected if the effect of the image of a picture falling on the blind spot meant that it was ignored. Nor was there any tendency, except for Group 1 Ss, for left-eyed viewers to find

TABLE 5.10

Percentages of AFEMs Obtained on 'Left'(L) and 'Right'(R) Trials for Left-Eyed (LE) and Right-Eyed (RE) Subjects

Groups	Faced Trials			
	L	R	L	R
G1	67.5	79.4	70.8	66.7
G2	87.5	71.9	65.6	68.8
G3	82.5	82.5	91.7	58.3
G4	93.8	93.8	96.9	90.6

it easier to look right more appropriately than left. On the whole, the ability of Ss to make AFEMs seem unimpaired by the locations of the image of the pictures falling on the retina.

Results for EM Pattern Measure. The results are summarized in Table 5.11. Not only did the kinds of patterns made differ significantly among themselves over all trials, but factors of Age and Truth Value both had a significant effect while the effect of Voice almost reached significance at the p=.05 level. Both ES and NES1 patterns were made significantly (T=60.6, N-29, Z=3.4, p=.001) more often than both SES and NES2 patterns, but did not differ significantly from each other. Significantly (T=66.5, N=28, Z=3.1, p=.001) more SES patterns were made than NES2 patterns.

The effect of Age interacted with that of Patterns with the order of preference for employing different search strategies varying with each group. Thus for Group 1 Ss,

TABLE 5.11

Factors Affecting the Number of "Faced" Trials on which Different EM Patterns were made.

Comparison	χ^2 Value	df	Level of Sig.	Mean Scores				
					ES	SES	NES1	NES2
Patterns (ES, SES, NES1, NES2)	150.2	3	.001		6.06 v	2.47 v	6.19 v	1.28
Patterns x Age	173.3	9	.001	G1	1.25	6.25	6.62	1.87
				G2	4.37	1.75	7.75	2.12
				G3	7.50	0.75	7.00	0.75
				G4	11.12	1.12	3.75	0.37
Patterns x Voice	6.86	3	.1 - .05	A	6.75	2.00	5.81	1.44
				P	5.37	2.94	6.56	1.12
Patterns x TV	26.7	3	.001	T	7.62	2.06	5.44	0.87
				F	4.50	2.87	6.94	1.69
Patterns x Age x Voice x TV	19.6	9	.05-.02	Affirmative True				
				G1	1.50	5.50	7.00	2.00
				G2	7.50	0.00	8.50	0.00
				G3	10.50	0.50	4.50	0.50
				G4	14.50	0.00	1.00	0.50
				Affirmative False				
				G1	2.00	6.50	5.50	2.00
				G2	1.50	1.50	8.50	4.50
				G3	7.50	0.50	6.50	1.50
				G4	9.00	1.50	5.00	0.50
				Passive True				
				G1	1.50	6.50	6.00	2.00
				G2	7.00	1.50	5.50	2.00
				G3	9.00	1.00	6.00	0.00
				G4	9.50	1.50	5.00	0.00
				Passive False				
				G1	1.00	6.50	8.00	1.50
				G2	1.50	4.00	8.50	2.00
				G3	3.00	1.00	11.00	1.00
				G4	11.50	1.50	2.50	0.50

significantly (T=0, N=7, p=.01, for each comparison) more SES and NES1 patterns were made than either ES or NES2 patterns, with no differences being found between ES and NES2 nor SES and NES1 patterns. However for Group 2 Ss significantly (T=3.5, N=7, p=.05) more NES1 patterns were made than ES patterns, but ES patterns did not differ significantly from NES2 or SBS patterns. For Group 3 Ss, ES and NES1 patterns did not differ significantly, but significantly (T=0, N=8, p=.01 for each comparison) more of these patterns were made than SES and NES patterns. For Group 4 Ss, instead of being one of the least preferred patterns of search ES patterns occurred significantly (T=0, N=7, p=.01) more often than NES1 patterns which in turn occurred significantly (T=2, N=7, p=.05) more often than SES and NES2 patterns. For all groups NES1 patterns were one of the most frequently occurring patterns of search. When interpreted along with the mean No.EMs measure, this means that for the younger groups, the irrelevant picture was fixated as often as the relevant picture, which was usually several times, whereas for the two older groups where fewer EMs were made, the irrelevant and the relevant pictures were usually only fixated the once if both were fixated. For all groups the irrelevant picture was rarely fixated more often than the relevant, indicating that for every EM to an irrelevant picture there was usually an attempt to refer back to the relevant picture. Thus to some extent the search patterns were constrained by the requirements of the task, even though it was only for the two older groups that totally selective searches were used to any considerable extent.

The interaction of the Voice and Patterns Factors reflected the fact that significantly (T=73, N=24, p=.05) more ES patterns were made to judge active sentences than were made to judge passive sentences, while no differences between actives and passives occurred in terms of any of the other patterns.

The interaction of Truth Value and Patterns Factors indicated that significantly (T=70, N=23, p=.05) more NES1 patterns were made on false trials, that significantly more (T=95.5, N=27, Z=2.3, p=.01) ES patterns were made on true than on false trials but that no differences in SES nor NES2 patterns were found between true and false trials. Thus, when the picture mentioned in the sentence was not in the specified location the S was more likely to refer to the irrelevant picture than on true trials when the S was more able to inhibit further EMs once the relevant picture had been found.

The significant interaction of the factors of Patterns,Age, Truth Value and Voice suggest that the way Ss become able to employ efficient patterns of search with age is a complex process involving the ability to deal with different truth values attached to sentences of various syntactic forms. Reference should be made to Table 5.12 for a summary of the significant differences found between groups for the various kinds of sentences as seen in terms of each search pattern.

TABLE 5.12

Results of the Individual Kolmogorov-Smirnov (N=8 throughout) Comparisons of the Patterns by Age, by Truth Value (TV) by Voice Interaction of Factors

Patterns	Voice x TV Sentences			
	Active True	Active False	Passive True	Passive False
	K_D p	K_D p	K_D p	K_D p
ES	G4>1 8 .01 G4>2 5 .05 G4>3 5 .05 G1 = G2 G2 = G3	G4>G1 5 .05 G4> G2 6 .05 G4>G3 5 .05 G1 = 2 G1 = 3 G2 = 3	G4>1 7 .01 G3>1 7 .01 G2>1 5 .05 G2 = G3 G2 = G4 G3 = G4	G3>G1 6 .01 G1 = G2 G1 = G4 G2 = G3 G1 = G4 G3 = G4
	K_D p	K_D p	K_D p	K_D p
SES	G1>2 6 .05 G1> 4 6 .05 G1 = 3 G2 = 3 G2 = 4 G3 = 4	G1>3 6 .05 G1>4 6 .05 G1 = 2 G2 = 3 G2 = 4 G3 = 4	G1> 3 6 .05 G1> 4 7 .01 G1 = 2 G2 = 3 G2 = 4 G3 = 4	G1>3 6 .05 G1 = 2 = 4 2 = 3 3 = 4
	K_D P	K_D p		
NES1	G2>G4 5 .05 G1 = 2 = 3 G1 = 4 G3 = 4	G1> 3 5 .05 G3 4 5 .05 G1 = G2 = G4 G2 = G3	G1=G2=G3=G4	G1=G2=G3=G4
NES2	G1=G2=G3=G4	C2> G4 6 .05 G1=2=3	G1=G2=G3=G4	G1=G2=G3=G4

Only ES and SES patterns showed much variation in terms of the frequency with which they were used by different groups on trials representing judgements of different combinations of truth value and voice. NES1 and NES2 patterns occurred with much the same frequency for all groups for true actives (AT), false active (AF), true passive (PT) and false passive (PF) trials.

The extent to which the ES pattern was used by the different groups varied with the kind of sentence. It was on the AT trials that there was the clearest evidence for development with age of the ability to inhibit irrelevant EMs. Group 4 made significantly more ES patterns than did Group 3, Group 2 or Group 1. Group 3 Ss made significantly more ES patterns than Group 1 Ss although Groups 1 and 2, and Groups 2 and 3 did not differ. Evidence for much the same sort of development was shown on AF trials with significantly more ES patterns being made by Group 4 than by Groups 3, 2 or 1. Groups 1, 2 and 3 did not differ significantly from each other. On PT trials, Groups 4, 3 and 2 made significantly more ES patterns than Group 1, but did not differ significantly from each other. On PF trials the only significant difference to occur was between Group 3 and Group 1. For passive sentences, especially false ones, it was difficult even for adults to make ES patterns.

When performance of the groups is considered in terms of SES patterns it was the youngest group of Ss who made more of this sort of pattern than did the older groups, indicating that even though Group 1 Ss seemed unable to make the most efficient sort of pattern, there is some evidence that they were able, to some extent, to distinguish and focus upon the relevant information. Thus, while they were unable to inhibit EMs to the irrelevant picture they were more likely than the other groups to refer back more often to the relevant picture.

<u>Results of the Comparison of Binary and Non-Binary Faced Trials</u>: When an analysis was made of the factors affecting the performance of Ss on four binary and four comparable non-binary false trials, all of the 'faced' kind, the results, which have been summarized in Table 5.13, more or less confirmed the results of the analyses for all "faced" trials. The AFEM results again confirmed that it is not the presence of the mentioned LO that determines the direction of the FEM since the presence of the LO in irrelevant location on binary trials did not lead the Ss to fixate that location first or more often than when an unmentioned picture filled in an irrelevant location as on non-binary trial. Indeed the results indicated that on the whole a binary array did not lead to a more inefficient performance than did non-binary arrays, since no differences in RTs, EMs or AFEMs were found between binary and non-binary trials. The only way in which binary arrays seemed to lead to more inefficient searches was that significantly (T = 85, N=25, p=.05) more ES patterns were made on non-binary than binary trials, as though some peripheral information led the S to continue search on binary trials.

Age and Voice Factors were again found to have a

TABLE 5.13

Factors Affecting Binary(B) and Non-Binary (B)

"Faced" Trials.

Measures	Comparison	F or χ^2 Value	df	Level of Sig.	Mean Score
RTs	Groups (1,2,3,4)	28.2	3/28	.01	4.64 v 2.60 v 1.54 v 1.84
	TV (B/NB)	-	-	NS	2.53 v 2.78
	Voice (A v P)	5.75	1/28	.05	2.53 v 2.79
	Voice x Groups	4.23	3/28	.05	A	4.17 2.56 1.55 1.81 B	5.11 2.64 1.3 1.87
	Side (L v R)	6.34 6.34	1/28 1/28	.05 .05	2.55 v 2.76
No EMs	Groups	22.19	3/28	.001	4.87 v 3.45 v 2.45 v 2.48
	TV	-	-	NS	3.16 v 3.47
	Voice	-	-	NS	3.25 v 3.38
	Voice x TV	8.17	1/28	.01	A P T	3.23 3.09 F	3.26 3.67
	Side	5.95	1/28	.05	3.12 v 3.51
AFEMs	Groups	3.36	3	NS	5.25 v 5.12 v 6.37 v 7.12
	TV	1.18	1	NS	6.4 vv 5.5
	Voice	0.42	1	NS	5.68 v 6.25
	Side	0.88	1	NS	6.37 v 5.56
EM Patt-erns	Patterns (ES,SES, NES1, NES2)	77.3	3	.001	ES SES NES1 NES2 1.94 v 3.78 v 1.44 v 0.84
	Patterns x Groups	109.1	9	.001	G1	0.50 3.37 3.25 0.87 G2	0.75 4.25 1.37 1.62 G3	1.37 5.62 0.37 0.62 G4	5.12 1.87 0.75 0.25
	Patterns x TV	10.59	3		B	1.25 4.12 1.68 0.94 NB	2.26 3.44 1.19 0.75
	Patterns x Side	14.47	3		L	1.87 3.81 1.25 1.06 R	2.00 3.75 1.62 0.62

significant effect on the Ss performance in terms of RTs and EMs. Group 1 took significantly ($p=.01$, $.001$ and $.001$ respectively) longer than Groups 2, 3 and 4, which did not differ significantly from each other although Group 2 tended to take longer than Groups 3 and 4. Group 1 Ss made significantly ($p=.001$ in each case) more EMs than Groups 2, 3 and 4 and Group 2 made significantly ($p=.001$ in both cases) more EMs than Groups 3 and 4. The Voice Factor was seen to affect performance in terms of RTs, with passive false sentences taking longer to judge than active false sentences. Voice also interacted with Truth Value so that the difference between the No.EMs made on binary and non-binary trials was significantly ($p=.01$) greater than the differences occurring between binary and non-binary active trials. More EMs were made on non-binary passive trials than on binary passive trials, which again suggests that fewer EMs were made when the mentioned picture was present. The effect of Patterns interacted with Age, with Group 4 Ss making significantly ($K_D = 8$, $N=8$, $p=.005$) more ES patterns than Group 1, 2 or 3 Ss, and Groups 2 and 3 making significantly more SES patterns than Groups 1 and 4. Group 1 Ss made more NES1 patterns than did any other group. Thus on the false trials the older the Ss the more efficient the search pattern used.

The only factor found to influence the performance of Ss on false trials which did not apply over all trials was that of side, or rather, whether a left or right FEM was necessary in order to fixate the relevant location.

The results showed that when the task involved looking left to make an AFEM less time was taken, fewer EMs made and more ES patterns made than when a right FEM was required. As suggested by the Patterns Side Interaction for all faced trials, Ss seemed to find it easier to look left and inhibit further EMs even when it was a false trial, than when they were required to look right.

Results for the "Behind" Trials in Terms of AFEM and Pattern Measures: The results have been summarized in Table 5.14. As was found for the "faced" trials none of the experimental variables affected performance in terms of the AFEM measure, since for all groups for each sort of trial the ability to direct FEMs appropriately was poor. In fact over all behind trials, on only 25.3% of trials were AFEMs made, while AFEMs were made on 79.0% of all "faced" trials.

For the pattern measure, both Age and Pattern factors were important. Again NES1 patterns were made significantly ($p=.01$ in each case) more often than were ES, SES, and NES2 patterns and significantly ($p=.05$ in both cases) more ES patterns were made than SES or NES2 patterns. The Age by Pattern interaction indicated that significantly ($p=.001$) more ES patterns were made by Groups 3 and 4 than by Groups 1 and 2, and significantly ($p=.02$) more NES2 patterns were made by Groups 1 and 2 than by Groups 3 and 4. Also significantly ($p=.05$) more SES patterns were made by Group 1 Ss than by any other group. The older the S the more likely it was that efficient searches would be made, but the level of performance was apparently too low for differences in terms of voice or truth value to emerge.

TABLE 5.14

Factors Affecting Performance on "Behind" Trials in Terms of AFEM and EM Pattern Measures.

Measure	Comparisons	χ^2 Value	df	Level of Sig.	Mean No.Ss				
AFEM	Age	0.48	3	NS		4.75 v 5.00 v 5.75 v 5.50			
	Voice	0.19	1	NS		4.62 v 5.87			
	TV	1.19	1	NS		5.0 v 5.5			
Pat-terns						ES	SES	NES1	NES2
	Patterns (ES, SES, NES1,NES2)	33.4	3	.001		2.06 v	1.00 v	3.69 v	1.37
	Patterns x Age	31.2	9	.001	G1	0.50	2.00	3.00	2.50
					G2	0.75	0.50	4.75	2.00
					G3	3.25	0.75	4.25	0.25
					G4	3.75	0.75	2.75	0.75

5.10. Summary of Factors Affecting the Performance of an Active/Passive Sentence Verification Task. The most important factor to consistently affect the Ss performance seemed to be that of age, with some improvement occurring in the performance of each older age group in terms of either RTs, Number of EMs or Search Patterns or all three. The ability to direct the FEMs appropriately was well-established at the pre-school age level. Even this finding may represent not so much a general ability to direct EMs appropriately in whatever direction is required, but rather a tendency for sentences describing relationships to elicit 'faced' FEMs whatever the specific relationship being described. The ability to search first in the "faced" direction may be well-learned by four years. Further experiments will be carried out to establish whether this is so.

Moreover, the ability of Group 1 Ss to give appropriate judgements of passive as well as of active sentences, brings into question some of the conclusions made by Sinclair (1969, 1972), Bever (1970) and Turner and Rommetveit (1967a) about the inability of young children to interpret sentences in anything other than an actor-action-patient sequence. In situations where the sentences are repeated several times, the LS is introduced and established prior to the presentation of the sentence and the pictures representing the LS and LO of the sentence are clarly distinguishable, it would seem that four year olds are on the whole able to make correct decisions about passives even when false in a binary way.

Some inklings of the ways in which performance comes to be improved with age can be gleaned by the way in which Ss come to be able to efficiently judge sentences with different voice and truth values. The fact that the young S first comes to ignore the irrelevant picture on true trials supports the contention which arose from the studies reported in Chapter 3, namely that the child starts off describing the arrays in terms of the pictures mentioned in the sentences and only as he grows older is he able to describe the array in terms of the relationship specified in the sentence. Thus on false trials the child will continue to seek for the picture mentioned as the LO in the sentence, even after fixating the relevant location. Some additional support for this view comes from the Ss' performance on the binary trials where, instead of more confusion arising out of the presence of the picture mentioned as the LO in the inappropriate location, the judgements took slightly less time and fewer EMs than on non-binary trials. It would seem that the presence of the picture mentioned as the LO, albeit in an inappropriate location, made it easier to generate an array description against which to match the sentence description, than did the absence of the mentioned picture.

These findings suggest that Glucksberg et al's (1973) assumptions about when self-terminating searches will occur, are not applicable to the performance of Ss from Group 1 who were more likely to terminate their search appropriately on true than on false trials. Even for Ss from older groups it was never the case that false trials were more quickly judged on the basis of fewer EMs than were the true trials. Even the adults who were generally able to make a judgement after one EM did not terminate their search of the relevant picture more quickly on false trials than on true ones.

The effect of the voice of the sentence also provided some ideas about how the Ss processed the sentence and used it to direct their search. Longer RTs and more EMs were made on passive sentences than on active sentences, suggesting that Ss had not decoded the passive sentences into their active form, but that as Wright (1969) has found, the Ss tried to either generate an array description that was ordered in the same way as the sentence or else they attempted to check the sentence directly against the array. Since for the passive sentences the FFP did not correspond to the first mentioned noun in the sentence, such a strategy would require the S to search for the first mentioned picture, this search operating firstly in the "faced" direction, and then to refer back to the other locations if it was not in the appropriate location and finally to attempt to relate these pictures to the FFP which corresponded to the second mentioned picture. This position does not correspond to the Huttenlocher view of how the child operates upon objects in order to relate them in specific ways.

Since there was no Age by Voice Interaction for the EM measure it would seem that some such matching strategy was used by Ss of all age groups. However the use of such a search strategy may be due to different factors for the older and younger Ss. The younger Ss tended to refer to more pictures more often, whether or not the sentence was active or passive, in a way that corresponded to their lack of awareness of what constituted strictly logically falsifying evidence. The older Ss however seemed to adopt this search strategy more because of the order in which they tried to match the sentence against the array. The Age by Voice Interaction for the RT measure meant that even though the adult Ss made more EMs on passives than on actives there was no similar increase in the time taken to judge passives, suggesting that although more EMs were made, the fixations were of a shorter duration. In order to further test this view about the order in which the sentence is checked against the array it would be necessary to ask Ss of various ages to judge active and passive sentences against arrays where the FFP represented the LO of the sentence. Such a study has not been carried out but stands high on the list of future experimental work.

The fact that no interaction of the Truth Value and Voice Factors was observed for either the RT or the Number of EM measures is in line with the findings of Gough (1965, 1966), but challenges the relevance of Clark's and Trabasso's 'true' models of sentence verification as well as Glucksberg et al's model. More than just confirming Gough's findings that truth value and sentence voice affect performance independently the EM measures suggest that some of the ways in which these two factors do operate are in terms of information selection as well as information processing.

The age of the Ss was also important in terms of what he learned during the course of the experiment as well as the way he performed overall. Subjects from Groups 1 and 2 improved more during the experiment than did the older Ss, who began operating closer to the optimal level. The younger Ss improved selectively, improving most on true trials as opposed to false trials. However the ability to handle passives relative to actives did not improve throughout the experiment.

Factors having more to do with the stimulus arrays rather than relating to the Ss' level of cognitive functioning, did not appear to greatly influence the Ss performance on this task. The presence of the specified LO and the particular arrangements of the pictures to the left or the right did not effect the Ss' ability to search the arrays when considered over all trials. However some results did indicate that it was easier for Ss to inhibit further EMs having made a left FEM than when a right FEM was made, although why this should have been so is not known. On the basis of studies of EM habits established for reading, it would be expected that Ss would find it easier to move the eyes from left to right than vice versa. Also for the younger Ss, the presence of the nearer (adjacent) picture led to more re-orientations of fixation than did the presence of the more distant (non-adjacent) picture.

The fact that cognitive factors played a more decisive role in organizing the Ss searches in this task than did perceptual factors is not to deny that in other situations where further aspects of the stimulus arrays (such as proximity of the pictures or degrees of illumination of parts of the array) are varied and examined, these more perceptual factors may prove to be more important, or at least to modify the powerful constraints of the cognitive factors.

CHAPTER 6

Measures of the Comprehension of 'In Front Of' and 'Behind'

Experiment 1. EM Measures

6.1. Introduction: In order to test children's ability to direct their EMs appropriately to both the 'faced' and 'back' side of the first fixated picture, it was decided to ask Ss of various ages to verify statements made about the relative positions of two of three pictures. These two pictures were two-dimensional representations of intrinsically faced objects as seen in profile and were of the same sort as illustrated in Diagram 4.1. The three pictures were horizontally aligned across the back of the box in locations A, B and C as described in Chapter 4.2, so that it seemed appropriate to describe a picture at A or C as being 'in front of' (IFO) or 'behind' (BD) the picture at B or else to describe the picture at B as being 'in front of' or 'behind' one of the pictures at A or C. This first type of description was labelled 'Directive' and the second type as 'Neutral'. If the S was searching efficiently when required to verify a sentence describing the position of A or C pictures relative to the picture as B, which was the first picture to be fixated, then one would expect the S to search to the faced side of the B picture for an IFO sentence and to the back or unfaced side of the B picture for a BD sentence. If the S habitually searched the faced side first whatever the sentence then he would not make AFEMs on BD trials. When the S was required to judge Neutral sentences, then the position to search could not be anticipated since the mentioned picture could be either to the faced or unfaced side of B for both IFO and BD sentences.

6.2. Subjects: Subjects were selected from four age ranges. The age range for each group, the mean age of the subjects and the number of subjects in each group are given below.

	Number of Ss	Mean Age	Age Range
Group 1	16	4;11	4;6 - 5;6
Group 2	12	7;3	6;5 - 8;0
Group 3	10	9;3	8;1 - 10;1
Group 4	12	29;0	21;0 - 42;0

The subjects were selected and trained in the manner described in Chapter 2.2.

6.3. Experimental Design: Each subject was given twelve trials composed of four practice trials and eight test trials. The sentences and arrays for each trial are listed in Appendix 6.1. The four practice trials, which were given in a fixed order, each required the S to verify a directive description of the array for that trial. Two trials referred to the IFO relationship and two to the BD relationship, each kind of description being true on one trial and false on another. The true descriptions were true, although another picture of the same kind was in the unmentioned location. In other words a cat would be in both IFO and BD the horse when the correct description of an array was "a cat is IFO/BD the horse". The false sentences were false because the picture specified as being related to the B picture was not present in the array. The practice trials were arranged in this way so as to indicate to the S that the trials were not necessarily binary and could not be searched efficiently by looking in either direction from B.

The Test trials were composed of four Directive and four Neutral sentences. On all trials the picture specified with respect to the B sentence was present only once in the array, so the sentence was either true or false in a binary sense. One IFO and one BD sentence was true for one trial and false on another trial for each of the Directive and Neutral set of sentences. For both the Practice and the four Directive trials the direction required for an AFEM (left or right) was counterbalanced across the IFO and BD trials for both truth values. For the Neutral trials the Direction in which the B picture faced was counterbalanced across IFO and BD trials. The Test trials were ordered so that the first four and the second four trials to be presented each included two Directive and two Neutral trials and within each group the truth values and kind of spatial relationship was balanced. Half the Ss in each group received one group of trials first, while the other half of the Ss received that group of trials second.

The number of Ss in each group viewing the arrays with a certain eye and signalling their judgement with a given hand were counterbalanced as far as possible within each group of Ss.

6. . Scoring: The RT and EM measures taken of each Ss performance were scored in the manner described in Chapter 2.4. However only the direction and appropriacy of the FEMs and the judgements made by Ss were analysed for the purposes of

discovering if Ss of various ages found it more difficult to make AFEMs on BD trials than on IFO trials, because there was a tendency to search in the faced direction from the FFP.

6.4. Analyses and Results: The examination of the data was influenced by the fact that many Ss did not judge the sentences according to the criterion deemed relevant for the purpose of eliciting EMs that could be judged as appropriate otherwise. Some Ss judged both true and false sentences as false because there was nothing IFO/BD the B-picture, but only a picture at each side of the B picture. In other words unless a picture was placed between the S and the B picture it would not be judged as being in front of B, nor would a picture be judged as behind B unless B partially occluded it from the S. It was observed that on some trials when such a judgement, labelled as "egocentric", was made the S would look to neither A nor C picture s but only at the B picture before making a decision. Such a search pattern was never made by Ss who made judgements according to a "faced" or "objective" criterion. The number of Ss making egocentric judgements and searching only the B position is given in Table 6.1.

Table 6.1. Number of Ss Making Egocentric Judgements (EJs) and Searches of Only the B Picture Over the Four Test Trials and the Four Practice Trials

	Practice Trials		Test Trials	
	EJs	B Searches	EJs	B Searches
G1	18	8	16	2
G2	27	0	26	0
G3	5	1	6	1
G4	3	2	0	0

It was because the sentences were not found to be entirely suitable for studying search strategies in young children that the experiment was concluded quickly with the number of Ss in the four age groups being unequal and rather small. The data raised again the issue of whether the search strategy and the judgement of a S is determined by his interpretation of the sentence or whether the judgement is determined by whichever search strategy happens to occur. However the data also provided some indications of which explanation was most likely and additionally raised some interesting questions about the adequacy of Piaget and Inhelder's (1967) description of the development of spatial concepts. It is for these reasons that the analyses and results will be considered in some detail.

Firstly, the number of Ss in each group making AFEMs on each trial was ascertained for the Practice trials and for the Directive test trials. For the Neutral test trials the number of Ss making 'faced' EMs, as well as the number of Ss looking first to the 'actual' location of the mentioned picture was found. These frequencies are given in Table 6.2. Friedman's Analyses of Variance were carried out to discover if there were any differences between groups or between trials for each set. Differences between groups were only significant ($\chi^2_r = 11.1$, $k = 4$, $N = 4$, $p = .0009$) for the four Directive test trials, with proportionately more AFEMs being made by Ss the older the age group to which they belonged. For the practice trials the probability of the differences between groups occurring by chance fell between $p = 0.3$ and

$p = 0.2$ ($\chi_r^2 = 4.12$, $k = 4$, $N = 4$). The differences failed to reach significance because of the poor performance of the adults on the first practice trial to be presented. A Cochrane's Q test showed that the number of adults making AFEMs differed significantly ($\chi = 20.8$, $N = 12$, $p = .001$) between trials, with the first trial being performed poorly compared to the other three practice trials, which were performed equally well. When a Friedman's Analysis of Variance was carried out on the results from the other three practice trials, the groups were found to differ significantly ($\chi_r^2 = 8.1$, $k = 4$, $N = 4$, $p = .02$) with more Ss from Groups 3 and 4 making AFEMS than those in Groups 1 and 2. There was 100% probability that the differences between the groups on the Neutral test trials occurred by chance, whether the number of Ss making 'faced' ($\chi_r^2 = 0$) or 'actual' ($\chi_r^2 = .09$) responses was compared.

The analyses of differences between trials for each set of trials showed that there was no significant difference ($\chi_r^2 = 3.2$, $k = 4$, $N = 4$, $p = .43-.39$) between the Directive test trials, nor between trials for the Practice set ($\chi_r^2 = 4.57$, $k = 4$, $N = 4$, $p = .25-.2$). For the Neutral set, differences between the number of Ss making 'faced' responses on the various trials were significant ($\chi_r^2 = 12.6$, $k = 4$, $N = 4$, $p = .001$) but differences between the number of Ss making FEMs to the relevant picture were not significant ($\chi_r^2 = 3.37$, $N = 4$, $k = 4$, $p = .39$).

Thus, when the Ss were able to predict the relevant picture locations, the older Ss were more able to make AFEMs

Table 6.2. Number of Subjects in Each Group Making AFEMs for Each Practice and Directive Test Trial and Number of Subjects Making 'Faced' FEMs for Each Neutral Test Trial

Trial Specification	Trial 1 (IFO/ True)	Trial 2 (IFO/ False)	Trial 3 (B/True)	Trial 4 (B/False)
AFEM as seen by E	A	C	C	A
Directive Test Trials				
G1	10	9	11	7
G2	7	6	8	7
G3	9	7	7	8
G4	12	11	9	12
Practice Trials	C	A	A	C
G1	8	6	6	8
G2	6	4	7	7
G3	9	6	5	8
G4	11	11	2	11
Neutral Test Trials	C	A	A	C
G1	10	10	3	10
G2	7	5	5	10
G3	5	5	8	6
G4	0	4	12	9

but no group found more difficulty in making AFEMs on any particular trial within a set of trials. It was only on Neutral trials that no significant group differences were found, as would be expected if there was no way that any S could predict the relevant picture location. Moreover it was on Neutral trials that more 'faced' responses were made on some trials than on others. Just which trials were found to elicit more 'faced' FEMs was examined by comparing across the four trials for each group by means of a Cochrane's Q test. Significant differences between the trials were found for Group 1 ($\chi^2 = 8.02$, df = 3, p = .05) and for Group 4 ($\chi^2 = 23.6$, df = 3, p = .001) but not for Group 3 ($\chi^2 = 3.5$, df = 3, p = .2). Group 1 Ss made fewer 'faced' responses on Trial 3 where looking in the 'faced' direction also lead to looking at the mentioned picture. There is no obvious explanation of why the youngest Ss would look more to the 'back' of the picture at B on this trial than on the others. It is also unclear why adults made fewer 'faced' responses on trials 1 and 2, especially for trial 2 since looking in the 'faced' direction would also have lead to the mentioned picture.

The differences between the four groups on the Directive test trials and on the Practice trials was further examined by means of a Chi-square test for independent samples, which was used to compare the groups on each trial. On the Practice trials significant differences were found between groups for trial 1 ($\chi^2 = 9.5$, df = 3, p = .05) and trial 2 ($\chi^2 = 15.8$, df = 3, p = .01). Differences between groups on trial 4 only reached significance ($\chi^2 = 6.6$, df = 1, $p = .01$) when the two younger groups scores were combined, as were the scores of the two older groups. Differences between groups on trial 3 didn't reach significance even when the scores were collapsed for the younger and older groups.

For the Directive test trials significant differences between the four groups were found for trials 1 and 4 ($\chi^2 = 7.8, 14.9$, df = 3, $p = .05, .001$ respectively) while on trial 2 a significant difference ($\chi^2 = 4.4$, df = 1, $p = .05$) was only found when the scores for the two younger groups were combined and compared with the scores of the two older groups. On trial 3 the differences between groups were to be found by chance with a probability of nearly 100%. This trial was the 'true BD' trial where the older groups made fewer AFEMs than on the other trials. The nature of the trials on which differences between groups were found would seem to argue against the notion that Ss look to the mentioned picture which is detected on the periphery.

A Chi-square test was carried out comparing the number of Ss in each group making AFEMs over all four Directive test trials. It was assumed that the Ss were acting independently on each trial. When the four groups were compared the differences were significant between the $p = .05$ and $p = .01$ level, but when Groups 1 and 2 were compared with Groups 3 and 4 they differed significantly (at the $p = .01$ level). The fact that Groups 1 and 2 did not seem to differ much in terms of the number of Ss making

AFEMs over all trials and all judgements does not reveal the very interesting differences that were found between the two younger groups in their performance of the task. To do this it is necessary to look at the number of Ss in each group who made judgements which were either consistently 'egocentric' or consistently 'faced' or sometimes based on an 'egocentric criterion' and sometimes based on a 'faced' criterion.

As can be seen from Table 6.3 proportionately more Group 2 Ss made consistently EJs than did Ss from any other group and proportionately fewer Group 2 Ss made consistently 'faced' responses than did Ss from any other group. The proportion of Ss making both sorts of judgements was about the same for Groups 1 and 3. What is also worthy of note, is that it was the two oldest Group 1 Ss (age 5;6 years) and the youngest Group 3 S (8;1 years) who also made consistent EJs.

Table 6.3. Numbers and Percentages of Ss in Each Group Making Consistently Egocentric Judgements (EJs), Consistently Faced Judgements (FJs) or Both During 11 Experimental Trials

	Group 1 (N=16)	Group 2 (N=12)	Group 3 (N=10)	Group 4 (N=12)
EJs	2 (12.5%)	5 (41.7%)	1 (10%)	0
FJs	8 (50.0%)	3 (25%)	6 (60%)	12 (100%)
EJs+FJs	6 (37.5%)	4 (33.3%)	3 (30%)	0

It would seem that it was between the ages of 5;6 and 8;1 that Ss were most unwilling to accept a 'faced' criterion as being relevant for the task at hand. Even Group 1 Ss who initially made quite a few EJs began to adopt a 'faced' criterion for their judgements during the course of the experiment. Since many of the judgements made by Group 2 Ss were inappropriate it is not surprising that Groups 1 and 2 did not differ in terms of the number of AFEMs made. In order to provide a more precise picture of the differences between the groups it was necessary to distinguish between the appropriacy of FEMs on trials where a correct judgement was made and those where a judgement was made for incorrect reasons.

Table 6.4 shows the number of Ss making AFEMs when a correct judgement (CJ) was made, and the Number of Ss making AFEMs when an incorrect judgement (ICJ) was made. The number of AFEMs made when ICJs were made has been further broken down so as to show the number of Ss making EJs and those making ICJs for other reasons. These frequencies have been given for the Directive test set of trials and the Directive Practice set of trials. In order to summarize the comparison, the proportion of Ss making CJs and AFEMs and the proportion of Ss making ICJs and AFEMs have been expressed as percentages in Table 6.5. The numbers of Ss in the proportions to be compared were too small to allow for the valid use of a test for differences between independent proportions. However inspection of the results shows a pattern which is meaningful in terms of other EM findings and in terms of the number of Ss making AFEMs regardless

Table 6.4. Number of AFEMs (B1) Made by Subjects Making Correct Judgements (A) Compared with the Number of AFEMs (B2) Made by Subjects Making Incorrect 'Egocentric' Responses and the Number of AFEMs (B3) Made by Ss Making Other Incorrect Judgements (C)

		Practice Trials				Test Trials			
		G1	G2	G3	G4	G1	G2	G3	G4
		N=16	N=12	N=10	N=12	N-16	N=12	N=10	N=12
Trial 1	A	9	3	9	12	10	6	9	12
(IFO/T)	B	5	1	9	11	7	5	9	12
	C	3	7	1	-	3	5	1	-
	B2	2	4	0	-	1	1	0	-
	D	3	2	-	-	3	1	-	-
	B3	2	1	-	-	2	1	-	-
Trial 2	A	11	5	9	12	10	4	8	12
(IFO/F)	B1	4	3	6	11	7	3	6	12
	C	5	7	1	-	5	6	2	-
	B2	2	1	0	-	2	3	1	-
	D	-	-	-	-	1	1	-	-
	B3	-	-	-	-	0	0	-	-
Trial 3	A	6	2	6	3	9	3	8	12
(B/T)	B1	2	2	5	2	8	2	6	9
	C	8	7	3	3	5	9	2	-
	B2	2	4	0	1	1	6	1	-
	D	2	2	1	6	2	-	-	-
	B3	2	1	0	1	2	-	-	-
Trial 4	A	13	6	10	12	9	6	9	12
	B1	8	6	8	12	3	4	7	12
	C	2	6	-	-	3	6	1	-
	B2	0	1	-	-	1	3	0	-
	D	1	-	-	-	4	-	-	-
	B3	0	-	-	-	3	-	-	-

of the judgement. It can be seen that on each of the Test trials more Ss from Groups 3 and 4 made AFEMs when they gave CJs than Ss who gave ICJs. For Group 2 Ss more AFEMs were made by those giving CJs than those Ss giving ICJs for three of the four trials. Only on trial 3 was an equal proportion of AFEMs made by Ss giving CJs and those giving ICJs. Only for Group 1 Ss and only on one trial were more AFEMs made by Ss making ICJs than by Ss making CJs.

Table 6.5. A Comparison of the Percentages of AFEMs Made by Subjects Making Correct Judgements (A Percentages) With the Percentages of AFEMs Made by Subjects Making Incorrect Judgements (B Percentages)

		Practice Trials				Test Trials			
		G1	G2	G3	G4	G1	G2	G3	G4
Trial 1	A	55.5	33.3	100	91.7	70.0	83.3	100	100
(IFO/T)	B	66.7	55.5	0	0	50.0	33.3	0	0
Trial 2	A	36.4	60.0	66.7	91.7	70.0	75.0	75	100
(IFO/F)	B	40.0	14.3	0	0	33.3	42.8	50	0
Trial 3	A	33.3	100	83.3	67.7	88.9	67.7	75	75
(B/T)	B	40.0	55.5	0	22.2	42.8	66.7	50	0
Trial 4	A	61.5	100	80.0	100	33.3	66.7	77.8	100
(B/F)	B	0	16.6	0	0	57.1	50.0	0	0

The results for the Practice set of trials confirm those of the test trials for the three oldest groups. For Group 1 Ss it happened that on three trials more AFEMs were made by Ss making ICJs than those making CJs. It would seem that Group 1 Ss did not initially direct their FEMs in accordance with their interpretation of the sentence, but that after some practice they did come to direct their EMs somewhat more efficiently on those occasions when their judgements were based on the appropriate criterion. For the three older groups, provided the sentence was interpreted appropriately, no practice was necessary.

Any conclusions about the relationship between CJs and AFEMs cannot be more specifically stated other than to say that AFEMs are associated with CJs. No critical test is available to decide whether the strategy which leads to an AFEM also leads to a CJ or whether those Ss who made AFEMs were then more able to make CJs either because the necessary information was available more quickly or because there was less confusion caused than when viewing and processing the other picture first. However the latter explanation is the less satisfactory of the two because most of the Ss from Groups 1 and 2 looked at all the pictures in the arrays at least once, except for those Ss who on some trials looked only at the B location. So it is difficult to see how making an AFEM would in itself lead to a CJ for these subjects. The data from Groups 3 and 4 is not decisive, since although the Ss were able to make a CJ after fixating only the two relevant picture the Ss also made AFEMs on most occasions.

Experiment 2. Manual Measures of the Comprehension of In Front of and Behind

6.5. Introduction: As soon as it became apparent that some children were not prepared or not able to adopt the criterion of IFO/BD that was relevant for the sentence verification task, a procedure was introduced to observe the way the Ss followed instructions to place a chosen picture (ChP) IFO/BD a specified picture (SP). The pictures were all of a two dimensional nature but the SP was presented either in three dimensional space or two dimensional space along both the fronto-parallel plane and the sagittal plane so as to observe the Ss choice between an 'egocentric' response (ER) or a 'faced' response (FR) when the two were opposed in various ways.

Although the procedure was not as extensive or as adequately counterbalanced for the order of presentation of the items as might be desired, the performance of the Ss suggested that Piaget's view of the pre-school child as being completely spatially egocentric was not true in all circumstances.

6.6. Subjects: The four age groups were composed of sub-groups of the Ss from Experiment 1. Only Group 1 Ss were fully represented. The number of Ss in each group, their mean age and range of ages are given below.

	Number of Ss	Mean Age	Range of Ages
Group 1	16	4;11	4;6 - 5;6
Group 2	8	7;4	6;7 - 8;0
Group 3	9	8;11	8;1 - 9;8
Group 4	10	28;0	21;0 - 27;0

6.7. Task: The S was seated at a table. For each experimental item the E presented the SP in a certain manner on the table in front of the S. The S was then asked to select a picture from a box of pictures and instructed to "Put the ChP IFO/BD the SP". When this had been done the E noted whether the S had taken account of the face and back areas of the picture (FR) or had place the ChP relative to himself (ER). For half the Ss on each group the E sat to the right of the S and for the other Ss the E sat to the left of the S.

6.8. Experimental Items: In order to describe the pictures used and the ways in which they were presented reference will be made to Diagram 6.1 which shows the various planes of space used and the axes along which the pictures were placed. The full list of instructions and arrays given in Appendix 6.2 also refers to this diagram.

Diagram 6.1. Planes of Spaces in which Experiment 6.2 Arrays Were Presented

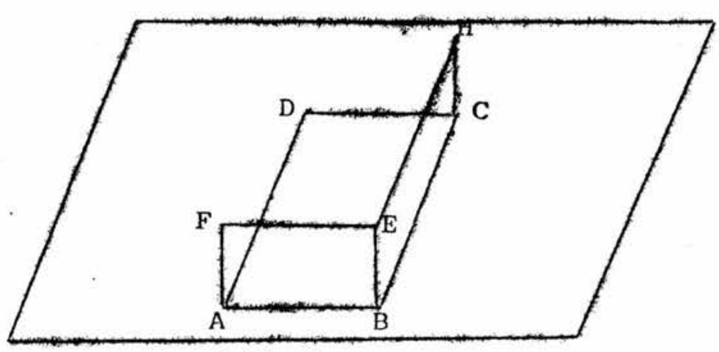


Table Top

S

X

Four items required the S to place his picture relative to a SP which was placed along the AB axis. The SPs represented an object seen in profile so that it was clearly seen to have a front and a back. For two items this picture was held in the ABEF plane by the E by means of a snap clasp attached to a long wire and for two further items the picture was placed flat on the table in the ABCD plane. For the two SPs presented on each plane, one instruction asked the S to place his picture IFO the SP and one instruction asked the S to place his picture BD the SP.

For the three dimensional presentations, a response, whether correct or incorrect, was scored as 'faced' if the SP was placed to the front or back end of the picture, in either a three or two dimensional way. Similarly a response was scored as 'egocentric' if the SP was placed between the SP and the S or else was partially occluded from view by the SP. For the two dimensional arrays the same criterion was used for FRs but ERs were further classified as either E_1Rs and E_2Rs. When a S made an E_1R the Chp was either inserted underneath the SP or else covered the SP. An E_2R response was made when the S placed the P above or below the SP as though using pictorial perspective to represent IFO and BD relations.

A further eight instructions were given using a SP which was two-dimensional but where one side of the paper represented the back of the object. For four of the instructions an SP of this kind was presented three dimensionally (BCHE plane) so that the picture faced along the

BC axis. For the other four instructions the SP was presented two dimensionally (ADCB plane) so that the picture faced either upwards or downwards along the BE axis. For each kind of dimensional array the S saw only the 'front' side of the SP on two trials and the 'back' side of the SP on the other two trials. An IFO and BD instruction were given for each kind of presentation. When the front side was visible to the S for both the three and two dimensional arrays FRs and ERs coincided. It was only on those trials when the S could not see the faced side of the picture, and thus had to place the ChP away from himself to place it in front by a faced criterion, that the Ss ability to make non-egocentric responses along the BC or BE axes was critically tested.

A final procedure was carried out whereby each S was asked to describe the position of the Y-picture when two pictures were arranged flat on table along the AB axis so that Y was IFO/BD the X picture by a faced criterion. The E said to the S "See the X. If the X was here, where is the Y?" If the S said 'there' he was asked to describe the arrangement of the pictures to a person who was out of sight. If this did not succeed the E placed a marble inside a cup and said "here's the cup. Where's the marble?" The E gave the response "inside the cup" if the S did not respond appropriately. The E then repeated "If the X is here, where is the Y".

The trials were ordered so that all Ss received those trials with the SP presented along the BA axis before receiving those trials with the SP presented along the BC or BE axis. Half the Ss in each group received 3-dimensional presentations first for each sort of axis presentation, and the other half received the 2-dimensional presentations first. The production trials were always presented last.

6.9. Results: The numbers of Ss in each group making either FRs or ERs for the various kinds of arrays are given in Table 6.6. Except for the responses on the two-dimensional B-E axis presentations, the responses have been given with the IFO and BD trials being treated as a pair. F_1Rs and F_2Rs were classified in the same way as for E_1Rs and F_2Rs.

Table 6.6. Number of Ss Making 'Faced' (FR) and 'Egocentric' Responses (ER) on Four Kinds of Presentation Trials (Varying the Axis and Dimensionality of the Specified Picture (SP)) and on a Production Task

SP Axis	B-A		B-C		B-E	Production Task
SP Dimension	3-D	2-D	3-D		2-D	
			Facing S	Back to S		
Group 1 (N=16)	13ER 3FR	9ER($6E_1$,$3E_2$) 5FR 3ER+FR	16FR	13FR 3ER	16F($8F_1$,$8F_2$)	14FR 1ER 1FR+ER
Group 2 (N=8)	5ER 3FR	4ER($2E_1$,$2E_2$) 4FR	7FR 1*	7FR 1*	7FR($2F_1$,$5F_2$)	8FR
Group 3 (N=9)	6ER 3FR	6ER($3E_1$,$3E_2$) 3FR	9FR	8FR 1ER	9FR($3F_1$,$6F_2$)	9FR
Group 4 (N=10)	6ER 3FR	3ER($3E_2$) 5FR 2ER+FR	10FR	10FR	10FR($7F_1$,$3F_2$)	10FR

*Indicates an Erroneous Response by either criterion

When the SP extended along the horizontal axis there was a tendency for Ss from all groups to make egocentric responses especially on the three dimensional arrays. Even on the two dimensional arrays, when the Ss were more constrained to make faced responses, Ss from the three younger groups made egocentric responses (E_1Rs), by inserting a picture underneath the SP for 'behind' instructions and placing a picture on top of the SP for 'in front of' instructions. These Ss seemed to be operating on a three dimensional basis along the B-E axis. Those Ss who made E_2Rs placed a picture above or below the SP as if operating in terms of 2-dimensional pictorial perspective. The 'faced' aspect of the SPs tended to be ignored when the picture was placed along the horizontal axis.

However when it came to placing a picture relative to a SP whose front/back corresponded to the vertical axis, even the youngest Ss were able to take note of the front/back cues. Thirteen Group 1 Ss were able to place a picture between themselves and the SP in response to a 'behind' instruction and to place the picture away from themselves in order to place it 'in front of' the SP which was facing away from the S along the B-C axis. Of the three Ss who made ERs, two ignored the front/back cues for both instructions and one S ignored the front/back cue only for the IFO instruction. The one S in Group 2 making an error on this type of presentation did so on the BD instruction when he placed the picture to the left side of the SP. The one S in Group 3 making ERs did so for both sorts of instructions. This S was the Group 3 S who consistently made ERs during the sentence verification task.

When the SP was placed two dimensionally along the BE axis either F_1Rs or F_2Rs were acceptable. The same S in Group 2 made inappropriate responses placing a picture to the sides of the SP for both instructions.

When it came to describing a two dimensional array along the horizontal axis only two Ss from Group 1 failed to describe the array in terms of an IFO/BD relationship. When the S is forced to code the relationship he seems to take account of the orientation of the SP, although when placing an object himself, he seems to prefer to do so with respect to himself rather than with respect to the SP alone. This is not to say that the orientation of the SP is necessarily overlooked since when the S was operating along the dimension corresponding to his line of sight he successfully took account of the face or back of the SP even though it was out of sight.

6.10. Discussion of the Results: The findings relating to the kind of criteria used by the Ss in the various groups to judge the IFO/BD sentences and to carry out the IFO/BD instructions indicate that Piaget and Inhelder (1967) may have under-estimated the capacity of preschool children to organize different objects, in terms of a common spatial structure independent of themselves.

On the basis of children's performance on the three-mountains task they claimed that it was not until a second stage of 'projective' space relations began to develop, at about school age, that the child began to understand spatial concepts like above and below, before and behind and left and right. According to their finding it was not until seven to eight years that children were able to begin to forcast the appearance of objects at different orientations and to ignore their own point of view. This ability was not sufficiently developed to allow for discrimination between perspectives and coordination of different perspectives until the child reached 11 to 12 years.

These conclusions were drawn from the performance of children who were required to work out quite a complicated set of transformations, where no familiar cues of front and back were given to indicate which mountains were to the fore and which to the rear from a given perspective. Moreover, when the child was asked to select the perspective that would be seen by a doll from perspectives other than the S's own, Piaget & Inhelder (1967, p.211) explicitly state that "the head of the doll is a plain wooden ball with no face painted on it so that the child can ignore the doll's line of sight and need only consider its position." Yet is is surely this cue which might assist the child to discover the perspective "seen" by the doll at the various positions. It seems reasonable to suggest that it is by the use of such cues that the child comes to the realization that some relationships between objects vary according to the perspective of the viewer and others remain constant.

Indeed, what was striking about the findings was that the preschool children were as able as the older children to make faced, non-egocentric responses when the SP was placed along the B-C or B-E axes, while the older children as well as the pre-school children preferred to make egocentric responses when a picture was presented along the B-A axis. Moreover it was children in the six to eight year age range who were most adamant in maintaining their egocentric criterion of 'in front of' and 'behind', while the younger children were willing to use the 'faced' criterion when the task constrained them to do so.

It may be that at some time between six and eight years the child experiences a decalage whereby the difficulty in sometimes treating a picture as an object which enters into only left and right relationships and sometimes treating a picture as an object when front and back results in the child simply ignoring the front/back criterion. The younger child, who was not concerned with left and right relationships would not experience this difficulty and older Ss, who have presumably resolved this difficulty would be able to operate well with whichever system of relations was required.

When the data was considered in terms of the relative difficulty of making AFEMs on IFO and BD trials, no evidence was available that it was more difficult to look first to the 'back' side of the FFP than to look to the front side. For the test trials the percentages of Ss making AFEMs when correct judgements were made was slightly less over both BD trials compared with both IFO trials (see Table 6.5) but no definite pattern of superiority on IFO trials emerged. A further attempt was made to determine if young Ss experienced more difficulty in directing their FEM's to the back of the FFP when it was appropriate to do so. This will be described in the next section.

6.10. Experiment 3: The Appropriacy of First Eye Movements in the Faced and Unfaced Directions on a Sentence Verification Task

Introduction: In order to examine the ability of pre-school children to direct their FEMs along both the faced or unfaced side of a FFP in accordance with the requirements of a sentence verification task, it was decided to describe situations in terms of relationships which were familiar to the child but were not expressed in explicit spatial terms. It was hoped that this would avoid the complications which arose from alternative interpretations being made of the same sentence as happened with IFO/BD sentences.

6.11 Subjects: Ten preschool children and ten adults were selected and trained in the manner described in Chapter 2.2. The preschool children which formed Group 1 had a mean age of 4;9 years (range 4;6 - 4;11 years) and the adults which formed Group 2 had a mean age of 27.0 years (range 22;0 - 35;0 years). Half the Ss in each group viewed the arrays with the left eye and the other half viewed with the right eye. As far as possible the hand used to signal the judgement was balanced across the Ss using each viewing eye.

6.12. Experimental Task: Each S was presented with four practice and eight test trials, each of which was to be verified against an array of three pictures arranged in the way described for the experiment described in Chapter 4.2. The Ss again initially fixated the picture at the B location so that the appropriacy of the FEM could be ascertained. Half the sentences required the S to look to the faced side of the FFP and half to the unfaced or back side. For example a sentence such as "the girl is chasing a duck" required the S to look in the direction in which the girl at B was facing whereas a sentence like "the girl is running away from a lion" required the S to look to the unfaced side of the girl at B. The actual direction (left or right) required for an AFEM was balanced across the true and false 'faced' and 'unfaced' sentences. The sentences and arrays used have been listed in Appendix 6.3.

The presentation of the task, the recording and scoring of the Ss' performances were the same as for other EM studies using horizontal arrays. However only the appropriacy of the FEM's was analysed so as to determine, for both groups, the extent to which the direction of the FEM was constrained by the sentence, or by a tendency to search the faced direction first, or else by a tendency to search first to the left or to the right.

6.13. Results: In order to compare the performance of the two groups the number of Ss in each group (N=10) making six or more AFEMs on the eight trials were compared by means of a Fisher Exact Test and found to differ significantly ($p = .005$). Nine adult Ss made six or more AFEMs whereas no Group 1 Ss made six or more AFEMs.

When the number of Ss in each group making five or more faced FEMs was compared, a significant difference was found ($p = .025$) with all ten Group 1 Ss making five or more faced FEMs, and only five Group 2 Ss making five or more faced FEMs.

No difference was found between the number of Ss in each group making five or more left FEMs with three Group 1 Ss and four Group 2 Ss making five or more left FEMs.

The results have been summarized in Table 6.7 in terms of the percentages of the kinds of FEMs made by each group.

Table 6.7. Mean Percentages of Kinds of FEMs for the Test Trials

	Group 1	Group 2
% AFEMs	57.5	86.25
% Faced FEMs	77.5	58.7
% Left FEMs	50.8	50.25

Thus, it would seem that unless the relationship described by the sentence is explicitly stated in spatial terms, preschool children tend to search an array in the direction in which the FFP is facing, with the exception that when the young S is not specifically asked to impose any relationship on an array, then neither the 'faced', nor 'unfaced' direction from the FFP will be favoured as was reported in Chapter 4.2. This may explain why young Ss were much better at efficiently searching arrays when search in the faced direction was required than would be expected by chance. This hypothesis will be further tested in the next experiment.

6.14. Experiment 4: Direction of FEMs Following Various Linguistic Instructions

Introduction: Since preschool children, who were instructed to look at three horizontally aligned pictures and tell the

E what they could see, showed an equal preference for looking in the faced and unfaced direction from the FFP, the findings from the active/passive sentence verification study seemed to suggest that, provided children were provided with specific task constraints, they would structure their search strategies accordingly. However the results of Experiment 3 which have just been reported, suggested that this may be too strong an argument since it was not supported by the evidence about preschool childrens ability to look to the unfaced direction when that was necessary. It may be that whenever pictures in the horizontal arrays were to be structured in any way which stressed relating the pictures, then the children would search the faced side of the FFP first.

<u>6.15. Experimental Task</u>: In order to test this suggestion, twelve preschool children (meanage 4;2, range of ages 3;2 to 4;11) were presented with the same sixteen arrays as were used in the study discussed in Chapter 4.1. However instead of being instructed to tell E what pictures they could see, the Ss were asked either to look at the pictures and tell E "What's happening" (Instruction A) or asked "What's the B-picture doing?" (Instruction B). A pilot test was carried out to evaluate instructions likely to elicit an attempt by the S to relate the pictures at least verbally if not visually. In this test it had been found that "what's the B-picture doing?" tended to elicit a description of the array from the S which related the pictures in some way, whereas the instruction to "look at the pictures and tell E what's happening" resulted in the same sort of listing of the pictures as was found when

preschool children were asked "what can you see". Instruction A rarely resulted in an attempt to read a relationship into the arrays. It was thus decided to compare the performance of Ss in terms of FEMs and verbal descriptions, when given Instruction A and B.

The Ss were divided into two groups with the six Ss in Group 1 being first given Instruction A when presented with the first eight trial and then given Instruction B when presented with the second eight trials. Group 2 Ss were given the arrays with the instructions being given in the reverse order. On the Instruction B trials, the picture at B-location was first presented to the S by itself for identification before the three picture array was presented with Instruction B. Half the Ss in each group viewed the arrays with the right eye and the other half viewed with the left eye.

It was expected that when Ss were given Instruction A, they would show a different pattern of FEMs to that made on Instruction B trials, assuming that Instruction B encouraged the S to relate the pictures together. It was expected that more faced FEMs would be made on Instruction A trials even though no specific relationship was described.

6.16. Results: Across both kinds of instructions Group 1 Ss looked in the faced direction of the FFP on 72.8% of all trials and Group 2 Ss looked in the faced direction on 80.2% of all trials. Thus the groups did not differ in the extent to which they both tended to look more in the faced direction than the unfaced. However the groups did differ in the way they responded to the two instructions. When, for each group, the number of faced responses made on Instruction A and on Instruction B trials were compared by means of Wilcoxin Matched Pairs Tests, Group 1 Ss made significantly (T = 0, N = 6, p = .02) more faced FEMs on Instruction B trials than on Instruction A trials and significantly (T = 0, N = 6, p = .02) more unfaced FEMs on Instruction B trials than on Instruction A trials. No such differences were found between the performances of Ss in Group 2 on the different trials (T = 1, N = 6) as can be seen from Table 6.8.

Table 6.8. Number of Trials on Which Faced (F) and Unfaced (UnF) FEMs Were Made by Each Group for Instructions A and B

G1				G2			
A Instruction		B Instruction		A Instruction		B Instruction	
F	Unf	F	Unf	F	Unf	F	Unf
29	19	41	7	39	9	38	10

Moreover the two groups also differed in the way they verbalized about the arrays with Group 1 Ss not relating the pictures together until the second eight trials when they were given Instruction B. However only one Group 2 S gave a 'list' description of the arrays.

Summary: It would seem that preschool children do not interpret 'what's happening?' questions in terms of relationships between pictures, unless they have been first given a clue about the type of relational response required by being given an instruction of the kind "what's B doing?" This was apparent from both the visual and verbal responses given by the Ss.

The results also indicate that even though the relationships between the pictures were not specified by the instructions the Ss tended to look in the faced direction of the FFP. This helps to explain why the visual search performance of young Ss was superior to chance when required to verify sentences requiring faced responses, but not superior to chance when required to verify sentences requiring unfaced FEMs.

Consider together, the results from the several studies requiring horizontal EMs, in response to linguistically mediated tasks, suggest that subtle differences in the interpretation of the meaning and presuppositions of linguistic messages may influence the way in which both young children and adults view the world.

CHAPTER 7

Developmental Differences in the Focus of Attention in Transitive and Intransitive Sentences

7.1 Introduction. The results of the EM studies have shown that the younger subjects have great difficulty in inhibiting their EM's once sufficient information has been acquired to allow for a judgement. Children between ages 5 and 10 years were better able to use verifying information to inhibit EM's but only teenagers and adults showed any success in recognizing falsifying information as being sufficient for a decision and using it to inhibit EM's until a decision had been made.

It was suggested that this might be a result of developmental differences as to which aspect of a sentence was regarded as important and was most easily manipulated in a cognitive sense. If the younger children were focussing on the nouns in the sentence, then one might expect the child to maintain the nouns as a reference point, whether the verification process is seen as the generating of an array description to match the linguistic description or as the framing of a question in order to interrogate the array. This would mean that if an array description was to be generated to compare with a linguistic description such as "the boy is chasing a dog" then an array description would be sought in terms of "the boy acting on the dog" rather than "the boy chasing an object". Alternatively it would mean that the question used to interrogate the array would take the form "Is there a dog?" and subsequently "what's the boy doing to the dog?" rather than "what is the boy chasing?". In either case more eye movements would be made when the logical object was not in the appropriate position.

If older children were more aware of the importance of the relationship denoted by the verb in a sentence, then they might be expected to maintain the verb as a basis for generating a description or interrogating the array. Since they would not need to search for a particular mentioned object this would account for their increasing ability to seek only the necessary information in order to make a decision.

However independent evidence is required in order to support this explanation of the EM results. Several studies have attempted to determine which aspects of a sentence are regarded by subjects of various ages to be of most significance for the grammatical and semantic structure of the sentence. These studies and their shortcomings will be discussed before a description is given of the two studies carried out in order to give a more precise picture of the developmental differences claimed by these studies.

Hornby, Hass and Feldman (1970) investigated which aspects of a sentence were significant for children of different ages. They labelled "what is talked about in a sentence" as the topic or psychological subject of the sentence and the "new information given about the topic" as the comment or psychological predicate. They tried to determine whether the psychological subject or the predicate was the most significant part of the sentence for children of various ages. In one task the children were asked to listen to a sentence and then say which word was the most important in the sentence. In another task they were asked to produce a sentence opposite in meaning to that given. They hypothesized that the comment or psychological predicate would be treated as the most significant part of the sentence and would hence be more often chosen as the most important aspect and chosen as the locus of change in generating opposites. The psychological predicate was assumed to correspond to the verb and grammatical object of the sentence. Two groups of eight children, mean ages approximately $5\frac{1}{2}$ and $7\frac{1}{2}$ were used for each experiment.

In one experiment, using an opposition task, the two age groups showed different patterns of responses. The older group were more likely to use negation, verb and preposition changes to produce opposition whereas the younger group were more likely to make changes of the subject or reverse the subject and object nouns. However as the task was given out of a context which validly required opposition, and as the task instructions were somewhat complex, it is dubious whether the younger children fully appreciated the range of responses possible. In fact in a second experiment using an opposition task, the instructions were changed so as to emphasize the use of negation to produce opposition. When this was done both groups negated the predicate in order to produce opposition. No evidence was given to show that if verb or predicate changes were similarly emphasized the younger subjects would not be just as able as older subjects to produce opposition in this way.

As for choosing the "most important" word in the sentence, the responses of the younger group were fairly equally distributed over the grammatical subject and object and the verb, although the subject and object were each chosen more often than the verb. However the older group of children chose the verb twice as often as both of the nouns together, the object being chosen more often than the subject.

Thus it would seem that there is some evidence for a shift with age to the grammaticl predicate, especially the verb, as the locus of the most important word. But issue must be taken with Hornby et al's contention that the grammatical predicate can be automatically equated with the comment and the grammatical subject with the topic of a sentence. Although they give no reasons independent of their results to support their claim, it is on this assumption that they base their conclusion that the comment comes to be the most important part of a sentence with the topic being regarded as unimportant because it is taken for granted. As the sentences were given out of context and were unmarked by intonational stress or definiteness of article, the subjects were free to take whichever aspect of the sentence they chose as the central pivot or focus of the sentence. There was no reason why the subject should not have been treating the verb or grammatical object as the topic - a point made by Hornby et al but subsequently disregarded. If the verb was taken as the thing talked about, then what the results indicated was that the 'topic' was of most importance for the older subjects and the comment for the younger subjects. However the only way to specify whether the topic or the comment is most salient is to establish one aspect of a sentence as the given information prior to a judgement being made about the importance of the various aspects of the sentence. As the results stand, they can only be taken to indicate the increasing saliency of the verb and grammatical object up to the age of seven or eight and a comparative lack of awareness of the importance of the grammatical role of a word by younger subjects.

Additional evidence pertaining to the importance of the verb comes from Healy and Miller (1970, 1971). In their 1970 study, adult subjects were required to sort sentences, which had either common agents or common verbs according to their similarity of meaning. They found that subjects sorted on the basis of verb rather than agents. A second study found that adult subjects judged sentences with the main verb deleted as less acceptable than sentences with the agent deleted. However they found that the presence of a verb was not necessarily more essential to the meaningfulness or comprehensibility of the sentence. Nonetheless they argued that it would be premature to discard the notion that the verb is more important to sentence meaning than the noun. They pointed out that their results were probably biased inasmuch as subjects tended to rate sentences as comprehensible so long as they could appropriately fill in a word and in their study both nouns and verbs could be easily specified from the context.

Another study relevant to this discussion was carried out by Hornby (1972) in which he tried to establish the independence of the psychological subject and predicate from the logical and grammatic subjects and predicates of a sentence for adults. The method used was similar to that used in the studies to be reported here. However it was more limited in scope inasmuch as the experimental subject was only required to choose between the importance of the subject and object of a sentence while the verb remained constant throughout. The task required the subject to choose which of two pictures best showed what a test sentence was about. Both pictures depicted scenes with the same action as that depicted in the sentence, but one picture showed the logical subject referred to by the test sentence while the other picture showed the logical object referred to by the test sentence. Thus for a test sentence like "The indian is building the igloo" the subject had to choose from two pictures, one showing an indian building a teepee and one showing an eskimo building an igloo. The rationale was that the picture selected would reflect which aspect of the sentence was regarded as the psychological subject. All test sentences described a transitive action but different sentence structures were employed so as to study in what way the psychological significance of each of the nouns depended on the grammatical and logical status conferred on them by the sentence structure.

The results showed that the picture containing the actor was selected for the active, cleft object and pseudo-cleft object sentence structures, while the patient or object was selected for the passive, cleft agent, pseudo-cleft agent and stressed agent sentence structures. Hornby concluded that the psychological subject and predicate distinction must be regarded as independent of the logical or grammatical structure of the sentence and as also being independent of the theme/rheme or topic/comment distinction. He does however note that the psychological subject and predicate can be related to intonation and to grammatical structure, and in some cases can be taken as a reflection of what is taken as the given information. This would seem to contradict the earlier conclusions drawn from the previously discussed study using children.

The conclusions from the previous study by Hornby et al were also limited by the fact that of the 16 sentences judged by each subject, 10 were transitive, 2 were intransitive with prepositional phrases, and only two were passive sentences. Thus the finding that the older subjects chose the grammatical predicate as more important than the grammatical subject regardless of the voice of the sentence was based on only two passive as opposed to ten active transitive sentences. Moreover, varying combinations of pronouns, animate and inanimate nouns were used in the subject and object positions so that the test sentences were not equivalent even for a particular sentence structure. This influenced the younger subjects who seemed to make their selection on the basis of semantic content. They chose the verb more often when only pronouns were available in the subject and object positions, perhaps because they were denied the opportunity to refer the nouns to any known object.

Other evidence is available which argues for a developmental change with respect to the perception of semantically organized events and dispositions to attend to specific elements within any particular event. However different aspects of a sentence seem to be salient depending on the measure used to indicate psychological importance. Segalovitch (1972) was concerned to see if the semantic organization of the imaginal system paralleled that of the verbal system, with particular reference to hierarchical organization of semantic relations within any imaginal event. In one experiment he tested 5-year old children's prompted memory for pictures under conditions of visual or verbal interference. The direct object was found to be a more efficient memory prompt than the agent under all interference conditions, whereas in an unprompted situation there was no difference between agents and direct objects in their probability of being recalled. These results contrast with those of Horowitz and Prytulak (1969) which showed adults found the agent was better recalled and a better prompt than the direct object or patient of a sentence. Tannenbaum and Williams (1968) however found that for adults the grammatical subject was the best prompt for both active and passive sentences.

Segalovitch used another measure of saliency in a task which required 6 and 10-year old children to match only pairs of pictures for similarity of meaning. The pictures differed in either the agent or action or patient aspects. Accuracy scores of the younger children indicated that the action element was the most salient, the patient element intermediate and the agent element least salient. Reaction time data showed the reverse pattern of results for the older children. Segalovitch concluded that different aspects of a sentence can assume different levels of relative importance depending on the particular task used.

Thus it was decided that before any conclusions could be drawn for the EM studies a fuller treatment was warranted of the psychological importance accorded to aspects of a sentence by subjects of various ages. With this aim in mind two experiments were carried out. The task common to both will first be described and then the rest of the experiments reported.

7.2. Experiments I and II

Task: The subjects were presented with either two pictures along with an intransitive test sentence or three pictures along with an active transitive test sentence. The pictures were related to the test sentences in particular ways. Each test intransitive sentence was constructed as an amalgam of the descriptions of the two different intransitive one-event pictorial scenes. For instance when a picture of a man waving and another picture of a chair rocking were both presented and described to the S, the test sentence either took the form "The chair is having" or "The man is rocking". Thus the agent aspect of one picture and the verbal aspect of the other picture would be combined to produce the test sentence. In the same way each transitive test sentence was derived as an amalgam of the three transitive one-event pictorial scenes which were presented with the test sentence. The agent aspect of one picture, the action aspect of another and the patient aspect of the third were taken and used in the same semantic role in the amalgam test sentence. For instance, if three pictures were presented to the S and described respectively as "The boy is beating drum", "The girl is patting horse" and "The lady is chasing the horse" then the test sentence might take the form "The boy is chasing the horse".

Each experimental trial was presented in the following way. The pictures were presented and each one described by a simple sentence. Then the subject was asked to choose which picture someone would be talking about if they uttered the test sentence as a description of one of the pictures. For the children the experimenter introduced the task in the following way:

"My little brother was looking at the pictures. He was trying to tell me about one of the pictures and he said '(Insert test sentence)'. I didn't know which one he was talking about. Which one was he talking about when he said 'Test sentence'? You show me. Which one did he mean?"

Adult subjects were asked to "pick which picture someone would be most likely to be talking about if they offered the test sentence as a description of one of the pictures, or in other words, which picture best went with the sentence". The experimenter attempted to present the picture descriptions and test sentences so that the subject, verb and object were equally stressed.

It was assumed that whichever part of the test sentence was thought by the subject to be central to the meaning of the sentence, it would be reflected by the choice of the picture containing that aspect.

7.3. Experiment I: This was a preliminary study which used only intransitive sentences and pictorial situations and was carried out in order to establish the feasibility of this approach with children. Two groups of 16 children were used, mean ages of 4;1 years and 7;7 years and age ranges of 3;6 to 4;9 and 6;8 to 7;7 years respectively. The younger group (Group 1) was recruited from the Psychology Department Nursery while the older group (Group 2) was recruited from a local primary school. Each group was comprised of an equal number of males and females. All children who were willing to participate in the game were used and were tested individually.

Experimental Sentences and Pictures. All the situations depicted by the pictures were described by simple intransitive sentences which was also the form of the test amalgam sentences (see Appendix 7.1). However it was possible for some of the verbs describing the actions to be used as transitive verbs in other contexts. This was due to the difficulty of assembling a sufficient number of completely intransitive verbs comprehensible to the youngest subjects. One of each pair of pictures had an animate subject and one an inanimate subject. The pairs were arranged thus so as to test with intransitive sentences Clark and Begun's (1971) contention that sentences with animate agents are more acceptable than those with inanimate subjects. If this were so, one would expect pictures with animate subjects to be chosen more often than those with inanimate subjects.

The pictures were drawn in black ink on 4" x 2" white cards and sealed with plastic. Each pair of pictures were attached to a sheet of paper so they were clearly separated, could be easily manipulated and placed on a table in front of the subject so that they were equally distant from a point directly in front of the subject.

Experimental Design. Each subject was presented with 4 practice trials and then 16 test trials. Each trial was devised by taking one situation with an animate subject and one with an inanimate subject, so that each pair of pictures produced two amalgam sentences.

Half of the subjects of each group received one of the amalgam sentences for each trial so that each subject received an equal number of amalgam sentences with animate and inanimate subjects. For each subject the position of the picture containing the subject referred to by the amalgam sentence was on the right on half the trials and on the left for the other half. For each picture position, the subject picture was first described on half the trials and described second on the other half. For each test trial the position and order of mention of the pictures were counterbalanced so that each of the eight possible combinations of pictures and amalgam sentences was sen by two subjects. The 16 experimental trials were randomly arranged and presented in the same order for all subjects.

Scoring: Each trial was scored as to whether the picture chosen contained the subject or the verb mentioned in the amalgam sentence. The number of subjects making more 'verb' choices was ascertained for each group as well as the total number of verb choices made by that group out of a possible 256, and the performance of the two groups was compared. The number of trials on which an 'animate' subject versus and 'inanimate' subject was chosen was also ascertained for each group.

Analyses and Results: A Two-way Partitioning of Chi-square showed that the way the picture corresponded to the sentence had a significant ($\chi^2_r = 18.8$, df = 1, p = .001) effect on the choice of picture. Also the age of the subject and the kind of picture/sentence correspondence interacted to significantly effect ($\chi^2_r = 25.4$, df = 1, p = .001) the choice of picture. A Wilcoxon Matched-Pairs Signed Rank test was used to test individual comparisons and showed that Group 1 Ss made approximately the same number of N-picture and V-picture choices (T = 65, N = 15 NS), while Group 2 Ss made significantly (T = 7, N = 14, p = .005) more V-picture choices than N1-picture choices. The results have been summarized in table 7.1.

Table 7.1. Percentages and Frequencies (in brackets) of Trials on which 'Verb' and 'Subject' Picture Choices were made by Group 1 and Group 2 Subjects

	Verb	Subject	Total No. Trials
Group 1	48.4 (124)	51.6 (132)	256
Group 2	70.7 (181)	29.3 (75)	256
Mean for Groups 1 & 2	59.6 (305)	40.4 (207)	512

No differences were found for either group in terms of the position of the picture or the order of mention. Fourteen of the Group 2 subjects, as compared to 9 of the Group 1 subjects, chose the verb picture on at least 50% of the trials.

No differences were found for either group in terms of whether an animate or inanimate noun was the subject of the amalgam sentence (See Table 7.2).

Table 7.2. Percentages and Frequencies (in brackets) of Trials on which Animate and Inanimate Subject Pictures were Chosen by Groups 1 and 2

	Animate Subject		Inanimate Subject		Average Percentage of Noun Choices	
Group 1	47	(62)	53	(70)	51.6	(132)
Group 2	48	(36)	52	(39)	29.3	(75)
Groups 1 & 2	47.3	(98)	52.7	(109)	40.4	(207)

7.4. Experiment II: Experiment I confirmed that the task revealed the same sort of developmental differences as found by other studies inasmuch as a shift was found towards the verb as the aspect of the sentence central to its meaning. However unlike Hornby et al's (1970) results where children of mean age 5;6 years showed a preference for the subject of transitive sentences, the younger group with mean age 4;1 years showed no evidence of preferring the subject or verb of the intransitive sentences. Experiment II was carried out to find out if the finding from Experiment I extended to transitive sentences when each group of subjects were given both transitive and intransitive sentences to judge against pictures.

Subjects: Three age groups were used with mean ages 5;1, 7;7 and 25 years and age ranges of 4;11 to 5;4, 6;11 to 8;0 years and 22 to 31 years respectively. Each age group consisted of 36 subjects with an equal number of males and females. The children were recruited from an Edinburgh primary school and came from a variety of backgrounds. All children of the appropriate age willing to participate in the study were used and tested individually. Half the subjects in each group received the intransitive trials first and the transitive trials on a second occasion a week later while the other half received the reverse order.

Intransitive Sentences and Pictures: The same sentences and pictures were presented in the same manner as described for Experiment I except that two additional experimental trials were also judged by each subject (see Appendix 7.1 for test trial numbers 17 and 18). Each of the four combinations of order of mention and position of the pictures was seen by nine subjects. In order to balance the number of subjects receiving each of the two amalgam sentences possible for each trial, four subjects received one amalgam sentence and five subjects received the other for two such combinations while the situation was reversed for the other two combinations.

Transitive Sentences and Pictures: The test trials using transitive amalgam sentences were constructed by compiling 54 transitive sentences each describing a single event which would be familiar to the youngest subjects. One picture was drawn to correspond to each of the sentences which were grouped into threes so that no noun or verb filled the same semantic role within each group. In order to construct one amalgam sentence from each group of three sentences, each sentence contributed one of its constituent parts to play the same grammatical semantic role in the amalgam sentence. The selection of the constituents was carried out randomly. This was chosen as a preferable alternative to presenting each of the six amalgam sentences which could be constructed from the three original sentences. To illustrate the construction process one might take the subject of the first, the verb from the second and the object from the third of the following three sentences - "The boy is kicking the dog" "The mother is cooking a cake" and "The father is flying the kite" - in order to produce "The boy is cooking a kite". Eighteen experimental trials were so constructed as well as four practice trials (see Appendix 7.2). The test trials were graded for the degree of their semantic anomaly. The nine sentences where no semantic constraints were broken were labelled as nonanomalous (NA). Five sentences which were anomalous, inasmuchas either a semantic restriction was broken between the subject and the verb or the verb and the object, were labelled as "semi-anomalous" (SA). Four sentences, which were labelled as "anomalous" (A) broke the semantic restrictions between both the object and verb and the subject and verb.

Each test sentence was presented once with each of the 36 possible combinations of order of mention of the three pictures and position of the pictures. Each subject received an equal number of trials on which the picture corresponding to the subject, verb and object of the amalgam sentence occurred in the various positions and orders of mention. The 18 trials were randomly arranged and the same order presented to each subject.

The pictures were drawn in black ink on white cards 4" x 6". Each group of three pictures was arranged along a strip of paper so that the left and right hand pictures were 4" equidistant from the central picture which was positioned on the table directly in front of the subject.

Protocol: The same instructions were given to the subjects as for the intransitive sentences.

Scoring: The picture selected by the subject was scored as to whether it corresponded to the subject, verb or object of the test sentence. The number of subject, verb and object picture choices were ascertained for each subject, each group and for each type of sentence graded for semantic anomaly.

Analyses: A Two-way Partitioning of Chi-square Test was used to examine the effects of the age of the S and the kind of correspondence between picture and sentence on the S's choice of picture for both transitive and intransitive sentences. A Wilcoxin Matched-Pairs Signed-Rank Test was used to test the significance of differences found on individual comparisons. In order to examine the effects of degree of anomaly of the transitive sentences on picture choice, a Friedman's Two-way Analysis of Variance by Ranks was carried out for each kind of sentence (NA, A and SA sentences), looking for any differences in the choice of pictures across the three groups. Again a Wilcoxin test was used to test for individual comparisons.

Results: Intransitive Sentences: The Partitioning of Chi-square for intransitive sentences indicates that significant (χ^2 = 52.7, df = 1, p = .001) differences existed between the frequency of N1-picture and V-picture choices and that significant (χ^2 = 138.3, df = 1, = .001) differences existed between the groups of Ss in their picture choices. As can be seen from Table 7.3 Group 1 Ss made significantly (T = 200, N = 35, X = 1.89, p = .03) more N1-picture choices than V-picture choices, while Group 2 Ss made significantly more (T = 206, N = 35, Z = 1.79, p = .04) V-picture than N1-picture choices; and Group 3 Ss made significantly (T = 39, N = 36, Z = 4.5, p = .00003) more N1-picture than V-picture choices. The choice of the N1-picture was not influenced by the animacy of the subject of sentence as can be seen from Table 7.4.

Table 7.3. Percentages and Frequencies (given in brackets) of Picture Choices Corresponding to the Subject (NI) or Verb (V) of 18 Intransitive Test Sentences for Three Age Groups

	NI Choices	V Choices
Group 1	62.2 (403)	37.8 (245)
Group 2	40.3 (261)	59.7 (387)
Group 3	72.2 (468)	27.8 (180)

Table 7.4. Percentages and Frequencies of N1 Picture Choices Corresponding to Animate (A) and Inanimate (IA) Subjects of Intransitive Sentences for Three Age Groups

	A. N1 Choices	IA. N1 Choices
Group 1	48.3 (194)	51.7 (208)
Group 2	48.6 (126)	51.4 (133)
Group 3	52.3 (246)	47.7 (224)

Results: Transitive Sentences: The Two-way Partitioning of Chi-Square showed a significant ($\chi^2 = 33.1$, df = 1, p = .001) effect for the kind of sentence/picture correspondence and a significant ($\chi^2 = 55.0$, df = 1, p = .001) effect of the interaction of the age of the S and the kind of picture on picture choice. For Group 1 Ss, significantly (T = 142,47, N = 33,31, Z = 2.5,3.9, p = .006, .00003) more N1-picture and N2-picture choices were made than V-picture choices, respectively, while the frequency of N1 and N2-picture choices did not differ (T = 286, N = 36, Z = .87, p = .19). For Group 2 Ss no differences were found in the frequencies, with which N1 and V pictures were chosen (T = 250.5, N = 34, Z = 0.8, p = .21) nor in the frequencies of N2 and V-picture choices (T = 230.5, N = 33, Z = .98, p = .16), whereas significantly more N1 than N2-picture choices were made (T = 192, N = 35, Z = 2.0, p = .02). For Group 3 Ss, significantly (T = 50.5, N = 30, Z = 3.7, p = .0001) more N1-picture choices were made than V-picture choices and significantly (T = 111.5, N = 32, Z = 2.9, p = .002) more

Table 7.5. Percentages and Frequencies (given in brackets) of Picture Choice Corresponding to the Subject (N1), Verb (V) and Object (N2) of Anomalous (A), Semi-Anomalous (SA) and Non-Anomalous (NA) Transitive Sentences for the Three Age Groups

	A		
	N1	V	N2
Group 1	38.2 (55)	19.4 (28)	42.4 (61)
Group 2	34.0 (49)	31.3 (45)	34.7 (50)
Group 3	43.0 (62)	29.0 (42)	27.7 (40)
Mean % for all groups	38.4	26.6	34.9
	SA		
Group 1	31.1 (56)	12.8 (23)	56.1 (101)
Group 2	31.7 (57)	33.9 (61)	34.4 (62)
Group 3	42.2 (76)	17.8 (32)	40.0 (72)
Mean % for all groups	35.0	21.5	43.5
	NA		
Group 1	36.8 (119)	19.1 (62)	44.1 (143)
Group 2	32.4 (105)	29.9 (122)	37.7 (97)
Group 3	37.7 (122)	30.8 (100)	31.5 (102)
Mean % for all groups	35.6	26.6	37.7
	Mean % for all Sentences		
Group 1	37.7 (244)	18.2 (118)	44.1 (286)
Group 2	32.6 (211)	36.1 (234)	31.3 (203)
Group 3	40.1 (260)	27.2 (176)	32.7 (212)
Mean % for all groups	36.8	27.1	36.0

N1-picture choices made than N2-picture choice, and significantly ($T = 94$, $N = 34$, $Z = 3.5$, $p = .0003$) more N2-picture choices than V-picture choices. That section of Table 7.5 giving the mean percentages of N1, N2 and V-picture choices should be referred to for precise information about the extent of the differences in picture choices.

The same pattern of results is evident from the number of subjects in each group choosing a 'verb' picture on more than 50% of the test trials. From Table 7.6 it can be seen that twice as many Group 2 as Group 1 and 3 subjects made predominantly verb choices for transitive sentences. Moreover nearly four times as many Group 2 as Group 3, and twice as many Group 2 as Group 1 subjects made predominantly verb choices on intransitive test trials

Table 7.6. Number of Subjects from Each Age Group of 36 Subjects Making Predominantly Verb Picture Choices for Transitive, Intransitive and Both Sentence Types

	Transitive	Intransitive	Transitive and Intransitive
Group 1	5	12	1
Group 2	12	22	12
Group 3	6	6	2

It can also be seen from Table 7.6 that the Group 2 subjects who predominantly chose the verb on transitive trials showed the same pattern of responses for intransitive sentences whereas subjects from the other two groups did not show such consistency in their responses across the two kinds of sentences.

Table 7.7. Friedman's χ_r^2 Values and Levels of significance for Comparisons of the Effect of Word-Picture Correspondence (W-PC) on the Percentages of Picture Choices for (1) Each Group over all Sentence Types and (2) Each Sentence-Type Over All Groups. (N = 3, K = 3 throughout)

Comparison		χ_r^2 Value	p =
Effect of W-PC	G1	6	0.028
for each group over	G2	0.5	1.0 - 0.944
all sentence types	G3	3.5	0.36 - 0.194
Effect of W-PC	A	1.13	0.94 - 0.53
for each sentence	SA	2.13	0.53 - 0.36
type over all	NA	0.5	1.0 - 0.94
groups			
Effect of W-PC on sentence types		4.7	0.194
Effect of W-PC on Groups		0.5	1.0 - 0.944

Table 7.5 also showed the effect of the degree of anomaly of the sentence on picture choice for each group and over all groups. Friedman's Analyses of Variance were carried out on the percentages given in Table 7.5 so as to examine the effect of age of subject and kind of sentence on picture choice. Table 7.7 gives the values of χ_r^2 and levels of significance arrived at when the percentages were ranked as equivalent if they fell within 4% of each other, or in other words, with a frequency of 5 choices for A-sentences, 7.4 sentences for SA-sentences and 13.1 choices for N-sentences.

For no sentence type was there a significant effect of the word-picture correspondence over all three age groups. This reflects the fact that the various age groups showed different patterns of picture preference for each sentence. This was especially noticeable for the NA-sentences where Group 1 made N2, then N1 then V-picture choices, whereas Group 2 made more V-picture choices than N1 or N2-picture choices and the adult group preferred N1-pictures to N2 or V pictures. For A and SA-sentences Groups 1 and 3 both tended to prefer N1 to V-pictures but Group 2 showed an equal preference for N1, N2 and V-picture choices.

Rather than the kind of sentence affecting the picture choice, the age of the Ss seemed to exert a more consistent effect on picture choice over all sentence types. For Group 1 Ss V-pictures were chosen less often than N1-pictures, which were in turn chosen less often than N2-pictures for all sentence types. For Group 3 Ss the V-picture was always less frequently chosen than the N1-picture, although whether the V-picture was less frequently chosen than the N2-picture varied with the kind of sentence. The effect of picture choice only reached a p = .194 level of significance. Only for Group 2 Ss did the word-picture correspondence not have any effect since each picture was more or less equally preferred.

Over all sentence types the effect of the word-picture correspondence was not at all significant (χ_r^2 = .5, p = 1.0-.94) since each group showed a different pattern of picture preference. Over all groups the effect of word-picture choice was non-significant (χ_r^2 = 4.7, p = .194) with the V-picture being chosen less frequently for each kind of sentence and the N1 and N2-pictures being chosen with approximately the same frequency.

7.5. Summary and Conclusions from Experiments I and II

Assuming that picture choice reflects to some extent the degree of importance attributed to either the subject, verb or object of active sentence, then the results of experiments I and II can be interpreted in the following way. Until about age 5 years the child seems indifferent to the role of a word in a sentence. It is then initially the noun which is seen as playing the more important part in the sentence, and is only at about 6.5 to 8 years that the child becomes more aware of the importance of the verb for the meaning of both transitive and intransitive sentences. Indeed at this age the psychological importance attributed to the verb seems to be strong enough to withstand the effects of anomaly. These results seem in general accord with a number of Piagetian-type studies which have shown the child of this age to be especially aware of the effects of transformations and actions.

For adults the verb is not seen as important in intransitive sentences but for transitive sentences the kind of anomaly did influence the saliency of the verb. Where no semantic restrictions were broken the subject was seen as only slightly more central to sentence meaning than either the verb or the object (S = 38%, V = 31%, 0 = 31%). Where both subject-verb and verb-object restrictions were broken the percentage of 'verb' choices rose to 44% but this dropped to 18% when only one semantic restriction was broken. The location and extent of the broken restriction in the particular sentences used probably accounts for the distribution of responses to the subject and object pictures. For A-sentences the restriction broken between the subject and verb was usually less severe than the break between verb and object. For instance for "the bird is milking a television" it is easier to imagine something animate milking rather than something inanimate being milked. It may be for this reason that after the verb, adults next preferred the subject rather than the object as the important part of the sentence.

For four of the five SA sentences used it happened that the verb object restriction was broken rather than the subject verb. These sentences could most easily be made semantically sensible with the fewest alterations by replacing either the object or the verb. Thus the sentence "the lady is riding the door" could be made meaningful if it was seen to be about "a lady painting a door" or "a lady riding a horse". However neither adults nor the 5 year olds attempted to maintain the verb when making their choice. The adults seemed to find the subjects and objects as equally central to sentence meaning while the five year olds found the object more important than the subject and the verb (S = 31%, V = 13%, O = 56%). The five year olds also found the object to be slightly more salient in the NA and A sentences, while the verb continued to be the least salient aspect of the sentences. This preference for the object may be partially due to a memory factor whereby given a preference for nouns, the last mentioned is most salient. With adults this consideration probably did not apply, while other factors may have an effect. For instance, in sentences otherwise unmarked for topic and comment the first noun may be taken by adults to be the most important even though they are aware of the constituent parts of a sentence and of the importance of each part being dependent on the information being sought from the sentence.

Thus it seems that there is some support, in terms of at least linguistic saliency, for the view that it is only as the child grows older that he becomes more aware of the role of the verb in the sentence as well as the possibility of manipulating it. Only then can the child learn to use information structured in terms of the relationship described by the verb rather than information structured in terms of objects. It seems most likely that once established this capacity continues to operate even though the subject of unmarked sentences comes to be regarded as the most important aspect of a sentence by adults. The ability to match a description of the pictorial array in terms of the relationship interacts with the truth value of the linguistic description, inasmuch as for a true linguistic description the array can be described or interrogated either in terms of the relationship or the objects present. Thus children as well as teenagers and adults would be expected to judge true sentences more efficiently than false ones. But with false sentences only those subjects able to describe the array in terms of the relationship would be able to judge the sentences efficiently. The results of this experiment suggest that this would not be expected from children of less than eight years and probably additional time is required for the child to learn to decide and manipulate whichever aspect of a sentence is appropriate.

CHAPTER 8

Search Strategies During the Verification of Positively and Negatively Quantified Sentences

8.1. Introduction: It was decided to investigate the development of search strategies made in order to verify universally quantified information expressed in both a positive (all, every) and a negative (no, none) form, since it is under these conditions that the efficiency of an exhaustive or selective search can be most easily evaluated against the appropriacy of the judgement. True judgements require an exhaustive search if they are to be made on the basis of the necessary information, whereas for a false judgement the search need only extend as far as the first falsifying instance.

The study was also concerned to discover how negative information was evaluated since most of the research on the topic has indicated how much difficulty it affords even to adults in memory, comprehension and reasoning tasks. Bruner, Goodnow and Austin (1956) reported on the difficulty of using negative instances in concept attainment tasks while experiments like those of Gough (1965) and McMahon (1963), which tried to establish the complexity of sentences in terms of syntactic differences, found that the semantic variable of affirmation/negation was very often more important. A series of studies by Wason (1959, 1961, 1963) found that the production or comprehension of sentences containing negative information took longer than for affirmative sentences. Wason (1965) and

Greene (1970) have suggested that negatives are easier to produce and comprehend in certain situations rather than others. These certain situations are ones which provide what Wason calls "contexts of plausible denial" and what Greene sees as the "signalling of a change of meaning".

Most of the work with adults usually expresses differences between performance on negative and affirmative sentences in terms of reaction times rather than errors of performance. One question that may be asked of the literature on the development of the concept of negation is at what stage children's performance can be assessed in the same way. For although Bloom (1970) and McNeill and McNeill (1968) report the early differentiation of the semantic functions of the negative, including the denial of a state of affairs within the child's own repertoire of grammatical distinction, Reid (1972) found that a variety of negative expressions like 'except', 'if only' and 'anything but' caused difficulty in comprehension for children as old as seven years.

Donaldson (1959) found that school children had difficulty in expressing information in a negative form and a later study (1970) found that five to seven year olds found negative descriptions hard to generate even when provided with specific alternatives against which to contrast a negative description. The comprehension of negative instructions to select certain items of an array was also poor. Feldman (1972) also found that when children were required to use the negative as a logical operator within a classification task they failed to make an exhaustive search of all the items within the set denoted by the negative description. Variables affecting the children's performance included the familiarity of the materials in the task, the ease of labelling the items and sets in the universe of objects under consideration and also the number of objects in the complementary set to that described. She found that children reached asymtotic performance between the ages of six and seven years on a simple task involving the description of one attribute of objects in a set in terms of a familiar negative idiom. Certainly by 12 to 13 years Neimark and Chapman (1973) found that S's were able to understand 'all' and 'none' when they were employed in both simple and compound propositional statements.

According to Slobin's (1966) findings the comprehension of the appropriacy of a negative description of ordinary pictorial situations seems to develop at about the same age. He found that while both adults and children found negatives more difficult than affirmatives for both active and passive sentences, with the effect being greater for children, this difficulty was in terms of reaction times rather than errors of judgement. He reported that for six year olds only 18.2% of all responses were errors and that two thirds of these errors were on negative sentences. This leaves 75.6% of all negative sentences which were appropriately judged. Much has been made of Slobin's mention of the finding that several of the youngest Ss refused to accept any negative sentence as true. However it should be noticed that the majority of the 16 Ss usually did make appropriate judgements. When reaction time measures were used children showed the same pattern of results as adults with false negatives being judged faster than true negatives. Thus, although the situations were often binary, by virtue of the fact that sentences were false because the reverse situation obtained, the Ss did not treat them according to the predictions of the 'conversion' or 'recoding' model of Clark and Trabasso.

Donaldson (1972) stresses the capacity of even younger children to judge negative statements and to follow negative instructions. Her findings come from a study of children's comprehension of the quantification of various relationships holding between two sets of objects. Positive quantifiers like 'all' and 'each' were dealt with competently by a group of 14 children ranging from 3;7 and 5;0 years in most situations where they could establish a one to one correspondence between the two sets of objects. However it should be noted that the ability to ignore potent natural ways of structuring the world (such as in terms of 'containership') and to rely on the syntax of the sentence to establish the scope of the quantifier did not seem to be well-established at this age and may have caused errors to be made on the judgements of positive quantifiers in some situations. A group of 17 Ss, ranging from 3;4 to 4;7 years was found to also be quite competent in their judgements of universal negative quantifiers with only 22% and 25% of responses being erroneous on true and false sentences respectively. For each of two negative sentence forms each S judged six negative sentences consisting of two true sentences and four false sentences when either 1, 3 or 4 elements of the array disconfirmed the sentence. The sentences described binary situations where doors were either open or closed, lights on or off and soldiers standing or lying down. The kind of negative idiom used ('none' or 'not any') did not affect the pattern of errors and in fact no systematic errors were apparent for the Ss except for one who treated 'none' and 'not any' as 'all'. Four children were able to handle both idioms correctly, while seven were only able to handle 'not any' completely correctly. More errors were made on that trial where only one element in the array disconfirmed the sentence, than on any other trial.

Several suggestions were made by Donaldson to explain those errors which were made. One suggestion emphasized the ambiguity of the words 'yes' and 'no' in affirming or denying a negative statement, while another associated explanation suggested that for some children difficulty arose because they coded the array in terms of both confirming and disconfirming aspects of the array as far as the sentence was concerned. Thus, when asked to judge the sentence "None of the (4) garages is open" when one garage door was open, some children seemed to be caught by the perceptual salience of the three shut doors as well as by the open door which disconfirmed the sentence saying "Yes, they ... one is but all the other three aren't." Such descriptions did not seem to be easily compared to the sentences.

The children's performance in terms of errors does not fit either the 'conversion' or 'optional recoding' model of Trabasso (1970) and Clark (1970) or their 'true' or 'response change' necessary and sufficient for an appropriate judgement. In this way it was hoped to discover if there was any development in the ability to use information from disconfirming instances and any development in awareness of the degree of extension required to judge universal quantifiers. To this end Ss of varying ages were asked to verify positively and negatively quantified sentences which varied in terms of the scope of the set quantified, the size of the complementary set and in terms of the truth values which could be ascribed to them.

Following Vurpillot's (1968) findings, it was expected that decisions would be based on more efficient visual searches as the child got older so that more comprehensive searches would be made for true sentences and more selective searches made on false trials. The appropriacy of the search was to be revealed by the number of pictures of a specified set being directly fixated at least once, and was to be shown more indirectly by the total number of fixations made up till the time of the decision. If the searches were appropriate then the RTs were expected to show faster processing of false sentences, not for the reasons put forward by Clark or Trabasso in their models, but because the sentences were being used selectively, either with or without recoding, to judge each aspect of an array. Thus the more disconfirming instances were present, the faster the judgement could be made. If the S coded the array positively and independently of the sentence then false judgements would be expected to be quicker but to be made on the basis of comprehensive searches. Only if negatively quantified sentences had to be recoded into a positive form along with a change in truth value and this recoding was done after the presentation of the array would one expect negative quantifiers to take longer. Since the Ss were given the opportunity to recode before the presentation of the array, no differences were expected between positive and negative false sentences which would both ideally involve one mismatch between sentence and array descriptions. By this argument however true positives would be expected to be quicker than true negatives since the first involved no mismatches and the second to involve two. Thus it was hoped that RT data would provide some clues as to whether the same model of sentence processing would be appropriate for Ss of different ages.

It was also hoped that the direction of the FEM would show the Ss spatial preferences in a situation where no particular direction was specified or was necessary for an efficient search.

8.2 Experimental Design: Sentences and Arrays: Each S was given six practice trials and ten test trials. These are listed and labelled in Table 8.1, which should be consulted in order to clarify the following description of the sentences and the arrays. The sentences in the practice and test trials were classified in the following three ways: (1) in terms of the truth value, either true (T) or false (F); (2) in terms of the quantifier, either affirmative (A) or negative (N); (3) in terms of the scope of the quantifier which referred to the size of the set of pictures referred to by the quantified aspect of the sentence as opposed to the size of the set of pictures present in the array. The size of the quantified set of pictures varied between the whole of the set of pictures in the array (6 or 4) and half the pictures in the arrays of four pictures. In Table 8.1 and in subsequent discussion the scope of the quantifier has been given in an abbrieviated form such as $6^{\pm}/6$ or $2^{\pm}/4$ where the size and sign of the first number refers to the presence (+) or absence (-) of that number of quantified pictures in the array compared to the total number of pictures in the array, which is given by the second number. For the practice trials the quantifier qualified the word "pictures" in such a way that the scope of the quantifier referred to all six pictures in the array. For four of the test trials the nature of the arrays was such that the quantifier, which qualified the first noun in the sentence, applied to only two of the four pictures in the array, while for the other six test trials the scope of the quantifier applied to all four pictures present in the array. Throughout the rest of the chapter the trials have been distinguished by designations which specify the three aspects of the situation described above. For instance a sentence like "All the pictures are dogs" which was false of an array consisting of six different pictures was labelled AF6-/6.

Practice Trials: The six practice trials required the S to judge three pairs of true and false sentences. One pair took the form "All the pictures are X", one took the form "None of the pictures are X" and the third pair took the form "There aren't any Xs", when X was the class name of a set of objects well-known to even the youngest Ss and the size of this set was specified as the set of pictures visible within the box. Thus there was one affirmative universal quantifier to be judged true and false and two kinds of negative universal quantifiers. Each of the sentences was judged against a different array of six pictures arranged so that three were aligned across the top

Table 8.1. Specification of Practice and Test Trials in Terms of Sentences, Arrays and Truth Values

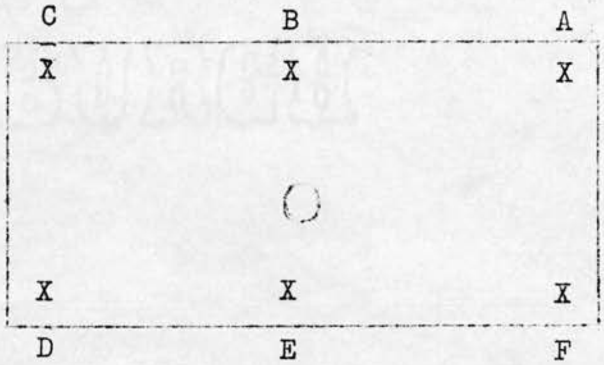
Type of Quantifier	Truth Value	Sentence	Array
Practice Trials			
Affirmative (All)	T(6+/6)	All the pictures are lions	6 lions
	F(6-/6)	All the pictures are spiders	No spiders, 6 different pictures
Negative 1 (None)	T(6-/6)	None of the pictures are elephants	No elephants, 6 different pictures
	F(6+/6)	None of the pictures are stars	6 stars
Negative 2 (There are no)	T(6-/6)	There are no horses	No horses, 6 different objects
	F(6+/6)	There are no trees	6 trees
Test Trials for Group A subjects*			
Affirmative (Every)	T(2+/2)	Every lady has a dog	2 ladies each with a dog and 2 men
	F(2-/2)	Every boy has a flower	2 boys, 2 girls each with a flower
Negative (No/None)	T(2-/2)	No boy has a flower	2 boys, 2 girls each with a flower
	F(2+/2)	No lady has a dog	2 ladies each with a dog and 2 men
Affirmative (Every)	T(4+/3)	Every boy has a flower	4 boys each with a flower
	F(4-/4)	Every lady has a dog	4 ladies, no dogs
	F(2-/4)	Every boy has a flower	4 boys, 2 with flowers
Negative (No/None)	T(4-/4)	No lady has a dog	4 ladies no dogs
	F(4+/4)	No boy has a flower	4 boys each with a flower
	F(2+/4)	No lady has a dog	4 ladies, 2 with dogs

* Group B subjects received the same test trials as Group A Ss defined in terms of truth value, quantifier and scope of quantification but each sentence was expressed and array given in the alternative form so that 'ladies' and dogs' replaced 'boys and flowers' and vice versa for any particular trial.

of the back face of the box and three across the bottom of the box as illustrated in Diagram 8.1. The picture locations were labelled A, B, C, D, E and F from top right to bottom right in an anticlockwise manner, as seen by the S.

The initial fixation point, which consisted of a luminous green spot and was located at the top of the hole, was labelled H.

Diagram 8.1 Practice Arrays



Average Maximum and Minimum Number of Degrees Subtended by Ss' Eye Movements Between Various Locations in Practice Trial Arrays

Direction of EM	Horizontal				Vertical						Diagonal			
	AP		NAP		P to H		P to P		P to H		AP		NAP	
Adjacent (A) or Non-Adjacent (NA) Pictures (P)	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
	20°	30°	52°	57°	12°	15°	24°	30°	$30^{\circ}30'$	$34^{\circ}36'$	$39^{\circ}30'$	$44^{\circ}12'$	$65^{\circ}42'$	$69^{\circ}54'$

The pictures were pasted onto three strips of grey paper which matched the paper lining the back face of the box. The middle strip had a hole cut into it so that it could be aligned with the camera hole.

Where more than one picture of a certain class was used, as in the true positive trials and the false negative trials, identical photocopies were used. In the case of the false positive and true negative trials each array consisted of six different pictures so that only at quite a general and abstract level could any one class name be used to describe them all.

Test Trials: The ten test trials were designed to assess the ability of Ss to judge the universal quantifiers "every" and "none/no" when the judgement process required the Ss to quantify a set of either two or four pictures out of four visible pictures, with respect to what shall be called the possession of an attribute such as 'having a dog' or 'having a flower'. For the negative trials the E gave the sentence once in the form 'None of the X has a Y' and once in the form 'No X has a Y'.

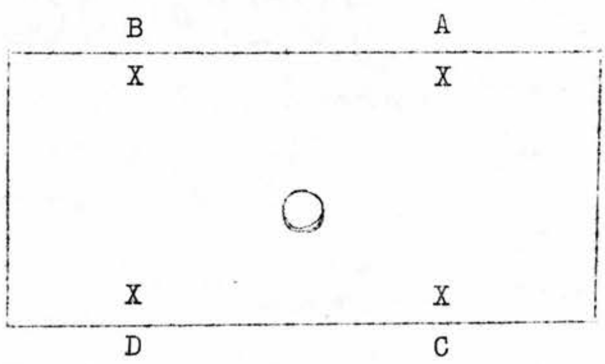
This was done to allow the S to judge the form with which he was most familiar. Donaldson (personal communication) pointed out that this may merely have confused the child if he did not recognize the sentences as being alternate forms. However ten young Ss who were recalled for further trials made the same responses when given only one form of the sentences as when they had been given two forms.

For each S half the trials required the S to judge sentences which referred to 'All/none/no ladies having a dog' and the other half to 'All/none/no boys having a flower'. These two relationships were used as a compromise between causing too much boredom or interference by requiring Ss to judge all the truth values against the same sort of sentence and causing confusion by requiring Ss to judge each trial using a different sentence and array. Moreover using many different sentences and arrays would have proved too time consuming in terms of establishing the relevant set of pictures to be judged for each trial. The kind of relationship used for each trial, as defined in terms of true value, quantifier and scope of the quantifier was the same for half the Ss in each age group, the other half receiving the sentence expressed in terms of the other relationship.

The scope of the quantified set was also varied in the test trials with the first four trials always consisting of sentences where the scope of reference of the quantifier was reduced to two of the four pictures present in the array. The remaining six trials involved judging sentences where the scope of the quantifier referred to all four pictures present in the array. These trials were presented second so as to avoid confusion over the size of the set being quantified. The first four trials consisted of two positive and two negative quantifiers one of each being true on one trial and false on the other. For one false negative and one true positive trial the relationship described by the sentence held for each of the two boys or ladies which were present, but not for the other two pictures present who did not possess the relevant attribute, nor any other in its place. For the true negative and false positive sentences the relationship described by the sentence did not obtain for the specified set, who possessed no other attribute, but did hold for the other two pictures which were present but not mentioned in the sentence. These first four trials were intended to provide a measure of how closely the Ss applied the quantification to the relevant pictures.

The remaining six trials consisted of three positively and three negatively quantified sentences, which all referred to all of the four pictures present in each array. Each sort of quantifier correctly described one array and incorrectly described two other arrays, one because the relationship did not obtain for half of the four pictures referred to as the quantified set. Again the affirmative sentences were false and the negative sentences true because the quantified relationship between each picture and its 'attribute' did not obtain, nor was any other picture present in its place. The order of presentation within the first four and the second six trials was counterbalanced across subjects with the added constraint that no more than two trials with the same truth value should follow one another. All the test sentences were judged against arrays containing pictures in the four positions A, B, C and D, as shown in Diagram 8.2. For the six trials on which only two pictures positions provided the relevant information, these two pictures were arranged so that on each of two occasions they were vertically, horizontally or diagonally aligned.

Diagram 8.2 Test Trial Arrays



Average Minimum and Maximum Number of Degrees Subtended by Ss' Eye Movements Between Various Locations in Test Trial Arrays

Direction of EM	Horizontal		Vertical		Diagonal			
					H to P		P to P	
	Min	Max	Min	Max	Min	Max	Min	Max
	24°	30°	24°	30°	$17^\circ 30'$	$22^\circ 30'$	$39^\circ 30'$	$44^\circ 20'$

8.3. Subjects: The selection and training of Ss was carried out in the same manner as for each of the previous EM sentence verification studies. Three groups of subjects with the following characteristics were used

	Number Ss		Mean Age	Range of Ages		
Group 1	16F	16M	4;6	4;1	-	5;3
Group 2	4F	4M	7;10	6;10	-	10;2
Group 3	4F	4M	26;0	19;0	-	27;0

In Group 1 half the Ss received Group A test items and half received Group B items. The four combinations of eye-used-for-viewing and hand-used-for-signalling a particular judgement were counterbalanced across each group so that one male and one female S performed either Group A or B test items under each condition. For the two older groups only one S performed under each eye/hand combination for Group A and Group B items with male and female Ss being assigned to alternate conditions.

Since only 30 Group 1 Ss provided full records on the practice trials, Group 1 was divided into three groups of 10 Ss for the purposes of analysing the practice trials and two additional Ss were run for Groups 2 and 3 for the practice trials only.

8.4. Protocol: The task and the procedure were the same for the S as on previous EM sentence verification studies except for two changes. For the test trials instead of requiring the S to identify the grammatical or logical subject of the sentence to be judged prior to the actual test trial, the S was presented with the four pictures making up the array against which the sentence was to be judged. Thus for the true and false 2+/2 and 2-/2 trials either two boys and two girls were presented or two men and two ladies. These pictures were always placed in the same positions as in the test trial. For the true and false 4+/4, 4-/4 and 2+/4 sentences, a set of four boys or four ladies were presented. During each of these "set establishing" (SE) presentations the E would ask the S to look at each of the pictures, pointing to any that were overlooked. At the beginning of the test trials and after the first four the S was asked how many boys or ladies they could see in order to establish the size of the set to be quantified. The S was then told that the E would turn off the lights and put some other pictures in the box. The E would try to guess what the pictures were. When the lights came on the S was to find out as quickly as he could if the E guessed right or guessed wrong. The SE arrays were always removed from the box before the lights were turned out even though they may have been returned as the test array. This was done in order to encourage the S to judge each sentence as a new description of a potentially new array. Before the practice trials began the S was presented with six pictures arranged in the manner described for the picture arrays. By monitoring the S's EMs on the video the E was able to ensure that all the picture positions were located. The S was then told that next there would be some new pictures in the same places. No other SE arrays were presented during the practice trials.

The second change in procedure involved directing the S to fixate a specified position other than H, prior to the onset of lights for certain test trials. This was down for the FA 2-/4, FA 2-/2, FN 2+/4 and FN 2+/2 trials so that the S would first fixate a picture which would provide him with the necessary disconfirming information to make a false judgement. This situation necessarily existed for the other trials requiring a false judgement. On these occasions the S was directed to fixate the green spot which was placed at either A or B rather than at H. The specified position was also pointed out to the S at the end of the SE array. On the set of false trials where the quantifier referred to two pictures, the S was required to initially fixate A on one trial and B on the other trial, while for the 4-picture set trials the positions were reversed for affirmative and negative sentences.

A break was given between the practice and the test trials for all Ss and also between the fourth and the fifth test trial for Group 1 Ss.

For some of the G1 Ss who were actually eager to judge more sentences at the end of the experimental session, extra trials were given, either repeating TN 4-/4 and FN 4+/4 trials or else asking the S to judge another pair of true and false negative sentences taking the form "there aren't any X". These last sentences were judged against practice trial arrays. For the repeated test trials the negative was given heavy intonational stress to see if this would help prevent the S from overlooking its importance for the meaning of the sentence.

8.5. Scoring: For each S, for each practice and test trial, the following measures were recorded: the judgement and its justification, the time taken to make the judgement and the number and order of fixations made on the various pictures. Where a S judged a sentence both 'right and wrong' this was counted as an erroneous judgement. From the search path record were derived scores for the number of pictures fixated at least once, the total number of fixations made apart from those made on H position and the direction of the first fixation. The television record of the EMs was scored in the manner described in Chapter 2.4.

The patterns of judgements for pairs of true and false trials were classified in the following ways. Where both true and false judgements for any one sentence were made correctly, this was called a Correct (CC) pattern. A Partially Incorrect pattern of errors (IC or CI) included a False Pattern of errors where the true judgement was incorrectly made (FF) and a True pattern of errors where the false judgement was incorrectly made (TT). Where both judgements were made incorrectly this was labelled a Reversal (II) pattern of errors and occurred when a true sentence was judged as false and a false sentence judged to be true. For instance if a S judged a sentence such as "None of the pictures is a star" as true when it was used to describe an array consisting of six pictures of stars, but judged the sentence as false when the array consisted of six different pictures (dog, cat, parcel, clock, snail, butterfly) then this would constitute a reversal (II) error.

8.6. Analyses: The scores for the practice trials were analysed and have been presented in their own right since they formed a consistent picture which confirmed that found for the test trials

8.6.1. Position Preference for FEMs: The frequency with which the first fixation was made on the different array positions was calculated for each group and over all groups for each practice and test trials. A One-sample Chi-square test was used to test differences in frequencies for each trial for Group 1 and over all groups. A Kolmogorov-Smirnov One-sample test was used to test differences between the frequencies found for Group 2 and 3 which were small in number. It was recognized that the effect of directing the FEM to the A or B positions on two of the first four test trials may have biassed the S to search the top positions first on subsequent test trials. Therefore the results from the practice trials were taken as being most informative with those from the test trials being of a more corroborative nature.

8.6.2. Judgements and Patterns of Responses Across Pairs of Trials: At this point the results must be anticipated sufficiently to say that for Group 1 the number of errors of judgement, especially for negative sentences, was far greater than had been expected. Since Group 2 and 3 Ss made correct judgements on nearly all trials, it is only for Group 1 scores that a Cochrane's Q test was carried out to confirm that significant differences existed between the number of correct judgements made on certain trials. A Partitioning of Chi-square analysis was also carried out to see if the type of quantifier or the truth value affected the judgements. A Binomial test was carried out for each trial comparing the number

judgements in order to decide if on some trials the pattern of responses differed from chance because of appropriate processing of the sentence, if on other trials it differed from chance because of inappropriate understanding of the sentence and on yet other trials if the frequency of responses did not differ from that expected by chance. In order to ascertain if the errors were the result of random or systematic responding the pattern of responses over pairs of affirmative or negative true and false sentences was examined by means of a One-sample Chi-square test on each trial.

8.6.3. Search Patterns: For each group the number of Ss making extensive and selective searches in order to judge true as opposed to false sentences was compared by means of a Wilcoxin Sign-Rank Test. In order to make the comparison meaningful only AT4+, NT4-, AF4- and NF4+ trials were used for the test trials comparison, since those subjects in Group 1 who did not fixate the green spot as instructed did not necessarily have the opportunity to make a selective search on those trials. A comparison of the sorts of search strategies used by the various groups was made by means of a Friedman Two-way Analysis of Variance.

8.6.4. Reaction Times and Number of EMs: For both practice and test trials the RTs and number of EM measures were analysed by a Four-way Analysis of Variance so as to examine the effects of the age of the Ss, the kind of quantifier (positive or negative) to be judged and the truth value of the sentence to be judged. For practice trials the Truth Value Factor only involved a comparison of T (6+/6 and 6-/6) trials with F (6-/6 and 6+/6) trials but for the test trials the Truth Value Factor involved comparison of the following five kinds of trials: T(4+/4, 4-/4); F(4-/4, 4+/4); F(2-/4, 2+/4); F(2-/2, 2+/2); and T(2+/2, 2-/2). These comparisons were made so as to ascertain if differences between RTs and between the No. EMs corresponded to differences in the kinds of search patterns used or whether additional difficulties in processing also seemed to be involved.

For Group 1 Ss the RTs and No. EMs made on incorrect and correctly judged trials were compared by means of the Student's T test for unequal groups when the numbers of Ss in the two groups were sufficiently large. The Mann-Whitney U Test was used to compare the number of pictures fixated at least once by the two groups for each trial.

8.7.1. Results: Judgements. The first result to be considered will be that of the appropriacy of the judgements made on each of the practice and test trials by each of the groups. It is in terms of these results that the other measures must be evaluated. Table 8.2 gives the number of correct judgements made by each group for each trial. A Cochrane's Q test was carried out on the Group 1 data for both practice and test trials and showed significant differences between trials for both sets of trials (Q = 1021, 4880, K= 6,10, N = 32, p = .001).

What is apparent from this table is that while Group 2 and 3 Ss were able to judge both practice and test trials with nearly 100% appropriacy the performance of the younger Ss was poor except for AT4+/4 and AF4-/4 trials and to a lesser extent AT2+/2 and AF2-/2 trials.

When the number of correct judgements made by Group 1 Ss on each trial was compared with the number expected by chance by a one sample chi-square test all the frequencies observed for practice trials differed significantly from chance. Affirmative sentences were judged incorrectly more often than expected by chance and negative sentences were judged incorrectly more often than would be expected by chance. When the number of correct judgements made on test trials was compared with that expected by chance more correct judgements were made on all affirmative trials than would be expected by chance except for the AF2+/4 trial which did not differ from chance. However, with negative sentences, only on the NF4-/4 trial were there significantly (at .01 level) fewer correct responses made than were expected by chance. On the other four negative trials

TABLE 8.2.

Frequency and Percentages (Given in Brackets) of Appropriate Judgements made on Each Trial

Practice Trials

Gp.	No. subjects	All T	All F	None T	None F	There are No T	There are No F
1	30	28(93.3%)	30(100%)	** 5(16.7%)	** 7(23.3%)	8(26.7%)	* 9(30%)
2	10	10 (100%)	10(100%)	7 (70%)	8 (80%)	8 (80%)	8(80%)
3	10	10 (100%)	10(100%)	10(100%)	10 (100%)	10 (100%)	10(100%)

Test Trials

Affirmative Quantifier

Truth Value		T	T	F	F	F
Scope		$2^+/2$	$4^+/4$	$2^-/2$	$2^-/4$	$4^-/4$
Gp.	No. subjects					
1	32	** 23(71.9%)	*** 31(96.9%)	** 25(78.1%)	15(46.8%)	*** 32(100%)
2	8	8(100%)	8(100%)	8(100%)	8(100%)	8(100%)
3	8	8(100%)	8(100%)	8(100%)	8(100%)	8(100%)

Negative Quantifier

		$2^-/2$	$4^-/4$	$2^+/2$	$2^+/4$	$4^+/4$
1	32	12(37.5%)	13(40.6%)	14(43.7%)	14(43.7%)	** 9 (28.1%)
2	8	8 (100%)	7(87.5%)	8 (100%)	8 (100%)	7 (87.5%)
3	8	8 (100%)	8((100%)	8 (100%)	8 (100%)	8 (100%)

*denotes a p=.02 level of significance for the probability of the frequency differing from chance as indicated by a One-sample chi-square test. Similarly ** denotes a p=.01 level of significance and *** a p=.001 level of significance.

the number of correct judgements did not differ significantly from chance (at the .05 level).

Thus false affirmative judgements were affected by presenting only two disconfirming instances instead of four, whereas for false negatives, presenting all instances as disconfirming resulted in fewer correct judgements than on other false negative trials. The most important factor to affect the Ss's judgements was whether an affirmative or negative quantifier was to be judged, with 79.6% of all test affirmative trials being judged correctly compared with 44.0% of all test negative trials. The actual truth value of the sentence did not differentially affect judgements nearly so much for either positive or negative trials as can be seen from Table 8.3.

Table 8.3

Frequencies and Percentages of Correct Judgements for True and False, Positive and Negative Test Trials

	Positive Trials	Negative Trials
True Trials	54/64 (84.3%)	25/64 (39.1%)
False Trials	72/96 (75.0%)	47/96 (48.9%)

Patterns of Responses. Lest it be thought that the younger Ss were simply responding randomly to the negative sentences the frequencies of patterns of responses made across pairs of true and false trials, (as seen in Table 8.4) show that the children tended to respond in quite a systematic way. The six pairs of affirmative and six pairs of negative trials for which the frequencies of the response patterns were ascertained for Group 1 were selected so as to show the consistency of judgements over

TABLE 8.4.

Number of Group 1 Subjects Making the Four Patterns of Responses for Certain Pairs of Trials

No.of Trial Pair	Prs of Trls		Correct Pattern	Patt. of Responses*				Sig.of diff. of frequency from chance
	1st Trial	2nd Trial		CC	II	CI	IC	
Affirmative Test Trials								
1A	4+/4	2+/2	TT	22	0	9	1	.001
2A	4-/4	2-/2	FF	25	0	7	1	.001
3A	4-/4	2-/4	FF	15	0	17	0	.001
4A	4+/4	4-/4	TF	31	0	0	1	.001
5A	4+/4	2-/4	TF	15	0	16	1	.001
6A	2+/2	2-/2	TF	18	2	5	7	.001
			Σ (TF) n=3	64	2	21	9	
Negative Test Trials								
1N	4-/4	2-/2	TT	7	14	6	5	.10
2N	4+/4	2+/2	FF	6	14	4	8	.10
3N	4+/4	2+/4	FF	6	14	8	4	.10
4N	4-/4	4+/4	TF	6	15	7	4	.05
5N	4-/4	2+/4	TF	6	11	7	8	NS
6N	2-/2	2+/2	TF	9	15	3	5	.02
			Σ (TF) n=3	21	41	17	17	
Practice Trials								
PA1	6+/6	6-/6	TF	28	0	0	2	.001
PN1	6-/6	6+/6	TF	2	20	3	5	.001
PN2	6-/6	6+/6	TF	4	17	4	5	.01

Prs of Trls = Pairs of Trials

* Pattern of Responses for 1st then 2nd Trial.

trials varying in scope but not truth value (1A, 2A, 1N and 2N pairs); trials varying in the number of disconfirming instances but not truth value (3A and 3N); trials varying in truth value only (4A and 6A, 4N and 6N); and trials differing in truth value and number of disconfirming elements (5A and 5N pairs). The pairs of trials selected from the practice trials varied only in truth value (PA1, PN1, PN2).

It can be seen from Table 8.4 that a 'reversal' (II) pattern of response was made more often than any other pattern on the negative trials and a fully correct response pattern was made more often than other patterns for all affirmative pairs except for the 5A pair. When a One-sample Chi-square test was performed on the frequencies of patterns for each pair of trials, only the 6N and 4N pairs of the negative pairs showed a pattern of responses which differed significantly (0.02 and 0.05 levels) from that expected by chance. Both negative practice pairs showed frequencies that differed even more significantly from chance (0.001 and 0.01 levels). For the pairs of affirmative trials all the frequencies differed significantly from that expected by chance (.001 level). The tendency to make a 'reversal' pattern of responses for the 1N, 2N and 3N pairs did not reach significance (at the .05 level). Taking into account the number of errors on the AF2-/4 trial as well as the errors on negative trials, it would seem that the presence of a specified picture caused many Group 1 Ss to give a judgement of true, regardless of the kind of quantifier being judged. Depending on whether the presence or absence of the named pictures was taken as being the most dominant feature of the NF2+/4 or AF2-/4 trials, these trials were judged true or false. Since absence and presence were balanced, it is not surprising to see that half the Ss judged each of these trials true and half judged them false. The presence of the named pictures also seemed to be powerful in reducing the number of correct false judgements made on the NF4+/4 trial. It is interesting to note that it was only on those trials where the named pictures comprised only half of the array that Ss gave judgements of 'Right and Wrong'- that bit's right and that bit's wrong' and were unable to assess the relevance of the sentence for the whole array. Thus on each of the AT 2+/2 and AF2-/2 trials two different Ss gave 'true and false' judgements and on each of the NT 2-/2, NF2+/2 and NF2+/4 trials one different S gave a 'true and false' judgement. No S gave such a judgement on the trials where the specified pictures were either completely present or absent.

That many Ss were consistent in their incorrect reversal pattern of responses can be seen from Table 8.5, which shows that number of Ss making each pattern of response over more than on pair of trials.

Table 8.5

Number of Group 1 Subjects Making the Same Pattern of Responses Across Certain Pairs of Trials with the Number of Ss Expected by Chance Given in Brackets

Pattern Consistently Maintained	Pairs of Trials			
	PN1 & PN2	Test 4N & 5N	Test 4N,5N & 6N	3 Test & 2 Practice Pairs
CC(TF)	2 (4)	4 (4)	2 (2)	1 ($\frac{1}{2}$)
II(FT)	12 (4)	9 (4)	9 (2)	5 ($\frac{1}{2}$)
CI(TT)	1 (4)	6 (4)	3 (2)	0 ($\frac{1}{2}$)
IC(FF)	1 (4)	2 (4)	1 (2)	0 ($\frac{1}{2}$)

It can be seen that the number of Ss making consistent responses dwindles as more pairs of trials are considered. Nonetheless, the likelihood of so many Ss making consistent reversal errors was far greater than would be expected by chance. The form of the negative sentence did not affect the judgements made on the practice negative trials, nor on the additional pair of "there aren't any Xs" sentences which were given to eight Ss, six of whom made reversal erros as they had done before. Most of the Ss who made repeated judgements on the NF4+/4 and NT4-/4 trials were consistent in their responses even though the experimenter stressed the negative aspect of the sentence. On the NT4-/4 trial one S made three false judgements over three presentations of the trial, two Ss made a false judgement on each of two presentations and one S changed from a false to a true response, while two Ss initially giving a true judgement continued to do so on the two repeats of the trial. On repeated NF4+/4 trials, three Ss gave three true judgements on three presentations, two Ss gave two true and one false judgements over three presentations and one S changed his judgement from true to false.

<u>8.7.2.</u> <u>Search Strategies</u>. The results showed that not only was there a development in the understanding of the negative universal quantifiers but there were also changes in the kinds of search strategies employed by the different groups. However, the development in comprehension of the task did not proceed in parallel with development of efficient search strategies. For task efficiency an 'exhaustive' search of all the pictures in the array was necessary on true affirmative and negative trials,

whereas a "selective" or less than complete search provided enough information for a judgement on false affirmative and false negative trials. Table 8.6 shows the number of Ss in each group who made exhaustive searches on each of the practice trials and for four test trials. The rest of the subjects made selective searches, which included all searches where fewer than the total number of pictures were fixated. It was decided to define "selective" searches in this way, because although one fixation on the false trials provided the necessary disconfirming evidence for a decision, even the adults seemed to find this insufficient information on which to made a judgement. Only three adults and one older child gave a correct false judgement after fixating only one picture on a practice trial and only two adults gave a correct false judgement after fixating one picture on a test trial. This was the case even though Groups 2 and 3 Ss followed instructions to fixate a disconfirming picture first. Group 1 Ss were less able to follow instructions to fixate a specified picture location and were thus less able to avail themselves of the opportunity to make an efficient search. Of those who did fixate the appropriate location none made a judgement on the basis of just that picture. On the AF4-/4 and NF4+/4 Test trials and the false practice trials, where any first fixation provided the necessary evidence, only three Group 1 Ss made a judgement after one fixation and only one of these judgements was correct.

Nonetheless by taking the less strict criterion of selective search the groups were shown to be using different search strategies. The number of exhaustive searches made

Table 8.6

Observed Frequencies (FO) of Ss in Each Group Making Exhaustive Searches on Six Practice and Four Test Trials as Compared with the Frequency of Ss Expected to Make Exhaustive Searches if Searching Efficiently (FE) or if Each Number of Pictures Has An Equal Chance of Being Searched (FC)

Practice Trials		AT6+	1st NT6-	2nd NT6-	AF6	1st NF6+	2nd NF6+
Group 1 N=30	FO	4	8	8	6	8	10
	FE	30***	30***	30***	0	0	0
	FC	5	5	5	5	5	5
Group 2 N=10	FO	6	8	8	6	7	9
	FE	10	10	10	0**	0***	0***
	FC	1.67	1.67**	1.67**	1.67	1.67*	1.67**
Group 3 N=10	FO	9	8	9	1	1	0
	FE	10	10	10	0	0	0
	FC	1.67**	1.67**	1.67**	1.67	1.67	1.67

Test Trials		AT4+	NT4	AF4-	NF4+
Group 1 N=32	FO	16	20	18	13
	FE	32***	32***	0***	0***
	FC	8	8	8	8
Group 2 N=8	FO	8	7	7	6
	FE	8	8	0***	0**
	FC	2**	2*	2*	2 (.06)
Group 3 N=8	FO	8	6	4	3
	FE	8	8	0*	0
	FC	2**	2 (.06)	2	2

* denotes a p=.05 level of significance of the difference between FO and each FE as found by a Fisher Exact Test or a Chi-square test. Similarly,

** denotes a p=.01

*** donotes a p=.001 level of significance.

across trials was found to differ significantly (.001 level) between the three groups for both the practice and the test trials when tested by a Friedman Two-way Analysis of Variance. The following picture of the search strategies used by each group emerged when the number of Ss that made exhaustive or selective searches on each trial was compared with both the number of Ss expected if an efficient search was being carried out and the number of Ss expected if each number of pictures was equally likely to be inspected. A Chi-square One-sample test was used to test the comparisons for the number of Group 1 Ss making exhaustive searches on the practice true trials and the test true and false trials. For the practice false trials the number of Ss making selective searches was compared with the two expected frequencies. For Groups 1 and 2 a Fisher Exact test was used to test the differences between the number of Ss making exhaustive searches on each practice and test trial and the two expected frequencies.

The number of Group 1 Ss making exhaustive searches on each of the practice true trials was significantly ($p = .001$) less than the number that would be expected if efficient searches were being made, but did not differ significantly from the number expected to make exhaustive searches by chance. So there is no evidence that Ss were searching efficiently on true trials.

The number of Group 1 Ss making exhaustive searches on practice false trials did not differ significantly either from the number expected if Ss were searching efficiently nor from the number expected to make exhaustive searches from chance. In other words, the number of Ss making some sort of selective search did not differ from the number expected if searching efficiently or by chance. Since however the number expected by chance was very close to that expected if the Ss were searching efficiently, it is difficult to know whether to ascribe the seemingly efficient searches on false trials to a planned inhibition of some EMs or to an inadvertent cessation of EMs. The latter explanation is most probable given that true trials did not elicit the sort of search strategy which they required.

Moreover since many of the Group 1 Ss were judging the two negative false trials as 'true' and the two negative true trials as 'false' it must be concluded that they did not vary their search strategies according to the demands of the task whether these are seen logically or in terms of their own comprehension.

8.7.3. Results for RT and No. EM Measures. The analyses of factors affecting these two measures have been summarised in Table 8.7 for the test trials and in Table 8.8 for the practice trials. As the sub-groups of Group 1 did not differ among themselves for nearly all comparisons, the mean scores for all pre-school Ss have been given in the tables for the sake of compactness of presentation.

Table 8.7

Factors Affecting the Performance of Ss on Test Trials in terms of RTs and No.EMs

Measure	Comparison	F Value	df	Level of Significance	Mean Scores
RTs (Secs)	Age (G1,2,3)	6.33	5/42	.001	4.89 v 4.40 v 2.15
	Quantifier (Aff/Neg)	-	-	NS	4.34 v 3.37
	Age x Quantifier	5.33	5/42	.01	A 5.03 3.94 1.99 N 4.76 4.86 2.31
	Truth Value (TV)	4.59	4/168	.01	$T(^{4+}_{4-}/4)$ $F(^{4-}_{4+}/4)$ $F(^{2-}_{2+}/4)$ $T(^{2+}_{2-}/2)$ $F(^{2-}_{2+}/2)$ 3.79 4.06 4.47 4.64 4.80
	TV x Quantifier	2.20	4/168	.1	*A 3.64 4.20 4.48 4.28 5.11 N 3.94 3.93 4.47 4.99 4.50
No.EMs	Age	2.88	4/52	.05	4.20 v 5.41 v 3.60
	Quantifier	-	-	NS	4.33 v 4.27
	TV	2.17	4/168	.1	* 4.20 v 4.03 v 4.52 v 4.47 v 4.28
	TV x Quantifier	2.02	4/168	.1	*A 4.00 4.23 4.60 4.33 4.50 N 4.40 3.83 4.44 4.60 4.06

* Mean scores for the Truth Value Factor have been given in the order specified for the first set of TV results namely: $T(4^{\pm}/4)$, $F(4^{\pm}/4)$, $F(2^{\pm}/4)$, $T(2^{\pm}/2)$ and $F(2^{\pm}/2)$.

8.7.3(i). RT Measures for Test Trials. RT Measures varied with the age of the subject, the truth value of the sentence and the interaction of age and the kind of quantifier to be judged. Additionally, the interaction of truth value and quantifier almost reached significance at the .05 level.

With respect to the Age Factor, Group 3 Ss made significantly ($p=.02$) faster judgements than Group 2 Ss and nearly made significantly ($p=0.1$) faster judgements than any of the preschool sub-groups. There were no significant differences between the mean RTs of Group 1 and Group 2 Ss. Thus, the pre-school Ss, who were not constrained to carry out the necessary searches in order to make a correct judgement, were more able to approximate the adults' speed of decision making than were the Group 2 Ss, who gave correct judgements which were often based on more information than was necessary for the decision. Adults, who were most able to base their correct judgements on information gathered from efficient searches whatever the requirements of the trial, were able to make the fastest judgements.

The kind of match or mismatch between the sentence and the array had a significant effect on RTs, with trials where all the pictures confirmed or disconfirmed the sentence being judged more quickly than trials where only half the pictures disconfirmed the sentence or trials where the scope of the quantifier referred to only half of the pictures in the array. The T(4+/4, 4-/4) trials were judged significantly ($p=.01$ for each comparison) faster than F(2-/4, 2+/4) trials, T(2+/2, 2-/2) trials and F(2-/2, 2+/2) trials. The F(4-/4, 4+/4) trials were judged significantly ($p=.01$ and $p=.001$) faster than T(2+/2, 2-/2) trials and

F(2-/2, 2+/2) trials. No significant differences were found between F(2-/4, 2+/4), T(2+/2, 2-/2) and F(2-/2, 2+/2) trials nor between F(4-/4, 4+/4) and T(4+/4, 4=/4) trials nor F(4-/4, 4+/4) and F(2-/4, 2+/4) trials. Thus the complete absence or total presence of the pictures referred to in the sentence lead to faster judgements than when the Ss needed to select which pictures were relevant for a judgement.

The interaction of the Age and Quantifier Factors was found to affect the RTs, with the difference between affirmative and negative quantifiers being significantly (p=.01) smaller for Group 3 Ss than for Group 2 Ss, and significantly (p=.02) smaller for one of the pre-school groups than for the Group 2 Ss. There were no significant differences between the size of the differences in RTs for the two quantifiers when judged by Group 3 and Group 1 Ss. The fact that none of the pre-school groups nor the Group 3 Ss showed large differences between RTs for different kinds of quantifiers presumably came about because Group 1 Ss treated the negatives as affirmatives, whereas the Group 3 Ss recognised the differences in meaning of the two kinds of quantifiers but were able to judge negatives as efficiently and easily as affirmatives. But for the older children, even though they were able to correctly judge negative quantifiers, there was still room for improvement in terms of the time taken to make that judgement. In other words, some of the problems of the negative trials for Group 2 Ss seemed to reside in matching the sentence and array representations after they had been generated since the same sorts of searches were made for both affirmative and negative quantifiers. The Group 2 Ss did not seem to be using the sentences to precisely anticipate the arrays but rather to loosely constrain the sorts of description they themselves generated about the whole array. The adults on the other hand used the sentence to anticipate what sorts of information would confirm or falsify it.

The interaction of the Truth Value and Quantifier Factors only reached significance at the 0.1 level, but the tendency to judge some combinations of truth values and quantifiers faster than others will be given some discussion as it corresponds to a similar trend seen in terms of the EM measure and provides some hints about the way search strategies are influenced. This interaction effect reflects the fact that a significantly ($p=.05$ at least) smaller difference in RTs was found between the affirmative and negative trials (namely, AF(2-/4) and NF(2+/4) trials) where for both trials the pictures mentioned in the sentence were present together at least once in the array, than was found for any of the other pairs of affirmative and negative trials where the mentioned pictures were present in one trial but absent in the other. For each of the comparisons of affirmative and negative trials made for the various truth values the time taken to judge the trial where the appropriate combination of mentioned pictures was absent was longer than the time taken on the trial where the appropriate combinations of mentioned pictures were present. The presence of the mentioned pictures in the array did not in itself reduce the number of EMs made by the Ss. It also seemed important that the mentioned pictures were associated in the way specified by the sentence. This was deduced from the finding that the difference in RTs between the AF(2-/2) and the NF(2+/2) trials was significantly ($p=.001$) smaller than the difference found between TN(2-/2) and TA(2+/2) trials and also smaller than the difference between the AF(2=/2) and AF(2+/2) trials. When one of the mentioned pictures was associated with an unmentioned picture a judgement took longer to be made than when the pictures mentioned in sentence were at least associated appropriately.

<u>8.7.3.(ii). EM Measures for Test Trials.</u> This measure was found to be less sensitive than the RT measure with only the Age Factor having a significant effect. Group 2 Ss made significantly ($p=.02$) more EMs than did Group 3 Ss, but with no significant differences occurring between the pre-school children and the adults nor between the pre-school children and the school age children. This corresponds to the RT results, although the difference between adults and pre-school children was greater in terms of RTs than EMs, presumably because the younger Ss made fixations of a longer duration than adults. This may be a reflection of either slower identification of each picture, slower comparisons of array and sentence representations or else a longer time to signal their decisions. The significance of the Age Factor also fitted with the findings about the kinds of search strategies characteristically employed by the different age groups. Group 2 Ss tended to make exhaustive searches even when they were not logically necessary, unlike the adults who made exhaustive searches only when necessary and unlike the Group 1 Ss who often failed to make exhaustive searches even when they were necessary. Thus the equivalence of the adults

and pre-school children in terms of the EM measure needs to be evaluated in the light of the appropriacy of the search and the judgement. Older children may have made more EMs than the pre-school children but they also gave appropriate judgements.

The fact that the kind of quantifier being judged did not affect the No. EMS is in accord with the findings that a majority of Ss, considered overall, failed to distinguish between affirmative and negative quantifiers in terms of the search patterns made and the pre-school Ss failed to distinguish between them in terms of their judgement.

The finding that the Truth Value Factor only showed a tendency ($p=.1$) to affect the EM Measure reflected the failure of a majority of Ss to employ search strategies which were appropriate for the true and false arrays. However, as was suggested by the findings using the RT measure, this result indicated that more EMs were made on trials, whether true or false, where the relevant information had to be selected rather than being immediately available in the sense that one of the mentioned pictures was either completely present or completely absent. This was seen from the findings that significantly ($p=.05$ and $p=.001$) more EMs were made on $T(^{2+}_{2-}/2)$ trials than on $T(^{4+}_{4-}/4)$ or on $F(^{4-}_{4+}/4)$ trials and significantly ($p=.02$) more EMs were made on $F(^{2-}_{2+}/4)$ trials than on $T(^{4+}_{4-}/4)$. Also significantly ($p=.001$) more EMs were made on $F(^{2-}_{2+}/4)$ trials when only some instances disconfirmed the sentence than when all instances disconfirmed the sentence as in $F(^{4-}_{4+}/4)$ trials. The one exception to this seemed to be when one of the mentioned pictures was associated with the unmentioned picture as was the case with $F(^{2-}_{2+}/2)$ trials where significantly (p=.05) more EMs were made than on $F(^{4-}_{4+}/4)$ trials.

The same pattern of results was found for the interaction of the Truth Value and Quantifier Factors in terms of EMs as had been found with the RT measure. Again, the interaction only reached the 0.1 level of significance but showed that for each comparison of the affirmative and negative quantifiers for the various truth values, it was on the trial where one of the mentioned pictures was absent that more EMs were made than on the trial where the mentioned pictures were present.
A significant difference occurred between the size of the difference between AF(2-/4) and NF(2+/4) trials which was very small, and the size of the difference between AF(2-/2) and NF(2+/2) trials, which again demonstrated the difficulty occasioned by trials where of the mentioned pictures, two were present in the array but not in the specified relationship.
8.7.3 (iii). Practice Trials. The practice trials were analysed separately not only because they were given to the Ss to familiarise them with the nature of the task, thus making the results more tentative, but also because the range of mismatches and matches possible between the sentences and arrays were restricted to those where all pictures confirmed or disconfirmed the sentence and because the kind of quantifiers included two forms of the negative quantifiers (Neg I and Neg 2). The kinds of factors found to affect the Ss' performance in terms of RT and No. EMs have been summarised in Table 8.8.

Table 8.8

Factors Affecting the Performance of Ss on Practice Trials
In Terms of RTs and No. EMs

Measure	Comparison	F Value	df	Level of significance	Mean Scores			
RTs	Age (G1,2,3)	6.43	4/45	.001		4.40	3.76	2.13
						Aff	Neg 1	Neg 2
	Quantifier	4.10	2/90	.05		3.61	3.67	4.17
	TV (T v F)	-	-	NS		3.90	v 3.73	
						Aff	Neg 1	Neg 2
	TV x Quantifier	4.78	2/90	.05	T	3.36	4.01	4.34
					F	3.86	3.34	4.01
No.EMs	Age (G1,2,3)	3.32	4/45	.05		5.19	v 6.58	v 4.60
						Aff	Neg 1	Neg 2
	Quantifier	6.65	2/90	.001		4.82	5.34	5.90
	TV	27.36	1/45	.001		5.87	v 4.84	
						G1	G2	G3
	TV x Groups	9.85	4/45	.001	T	5.41	6.77	6.33
					F	4.98	6.40	2.87

8.7.3 (iv). Practice and Test Trials. There were no significant differences between the performance of the pre-school children making correct judgements and those making incorrect judgements on any of the measures, indicating that for the pre-school S, coming to an appropriate judgement does not necessarily reflect a more efficient selection and processing of the information on which the judgement was based.

Considered overall, the results suggest that the development of efficient performance on this task, needs to be seen as extending over a long time period, so that even when the correct criterion for judgement is acquired, further development in terms of efficient searches, especially on false trials, is necessary.

With the practice trials the factors of Age, Kind of Quantifier, Truth Value and an Interaction of Truth Value and Quantifier all significantly affected the S's performance in terms of the number of EMs. As with the test trials, Group 2 Ss made significantly ($p=.02$) more EMs than Group 3 Ss, but none of the pre-school groups differed significantly from Group 2 Ss nor Group 3 Ss, although there was a tendency for Group 1 Ss to make more EMs than the adult Ss. Improvement in performance in terms of the No. EMs does not come about simply because the appropriate criterion for judgement is applied, but rather requires further development before the search pattern employed is both sufficient and efficient.

The Kind of Quantifier to be judged was also important since significantly ($p=.001$) more EMs were made to judge the Negative 2 trials than to judge the Affirmative trials. However, since no significant differences were found between the two kinds of negative quantifiers nor between the Affirmative and Negative 1 trials, it would seem that the negative aspect of the quantifier was not necessarily critical in eliciting more EMs but rather the particular idiomatic expression of the negative.

Truth Value also affected the No. EMs with significantly ($p=.01$) more EMs being made for true trials than false trials. This may be attributed to one or other, or a combination of the following two factors. Firstly, for those Ss susceptible to the logical constraints of the task, the T trials would require more EMs of necessity. Those Ss not aware of the necessity for exhaustive search on true trials were also those Ss who treated negatives as equivalent to affirmative quantifiers. Thus, for these Ss two out of three of the T trials may have been judged as false. A tendency for Ss to make more EMs however unsystematically on these trials would indicate the same sort of search pattern as found in previously reported studies with young Ss making more EMs on false trials in an attempt to find the picture mentioned. An Age by Truth Value Interaction revealed that Group 3 Ss showed significantly ($p=.001$) larger differences between true and false trials than did any of the other groups, although the direction of the difference was the same for the other two age groups, with more EMs being made on true than on false trials.

The RT Comparisons for the Practice trials showed the same pattern of results as was found for the EM measures, except that the effect of Truth Value was not significant by itself but did interact with the kind of Quantifier. Differences between true and false trials were significantly greater than for 'All' trials. Significantly ($p=.05$) longer was taken to judge False than True 'All' trials and significantly ($p=.01$) longer taken to judge True 'None' than False 'None' trials. Since for many Ss the True 'None' trial was treated as a False 'All' trial the RT results favour the explanation suggested before, namely, that a majority of the Ss were seeking the pictures mentioned in the sentences, thus making more EMs and taking longer on False trials than on True trials which did not elicit the exhaustive searches necessary for an appropriate judgement.

No differences were found between True and False trials for the "There are no X" kind of quantifier, both of which took longer to judge than the comparable truth values for other quantifiers.

8.7.3 (v). Direction of FEMs. The final aspect of the results to be considered is whether the Ss showed any preference to first fixate a particular position when no instructions were given and no picture was known in advance to be particularly relevant or informative. The frequencies with which each picture position was first fixated were found for each group for the six practice trials and the four test trials where the search began at H position. The frequencies over all Ss for each trial were compared by means of a One-sample Chi-square test for differences between the left and right, or left, right and middle positions. The frequencies were also compared for each trial for interaction differences by means of a Chi-square test for independent samples. The results are summarised in Table 8.9.

Five test trials showed a tendency for the Ss to fixate a top position first, the difference being significant at the .05 level for two and at the 0.1 level for three of the trials. On the remaining trial no significant preference for either the top or bottom positions was found. As regards the left/right preference of Ss, three test trials showed a preference for the left, two such differences being significant at the .05 level and 1 being significant at the .01 level. On two trials the top left position was first fixated more frequently than would have been expected by chance, one at the .05 level and one at the .01 level.

Table 8.9

Frequencies of All Ss First Fixating Each Picture Position on Six Practice and Four Test Trials

	Frequencies for Groups 1, 2 & 3						Level of Significance for Differences from Expected Frequencies		
	TR	TM	TL	BR	BM	BL			
Expected Frequency	8	8	8	8	8	8	1-sample chi-square/2xk chi-square		
							T/B	R/M/L	Interaction
Practice Trials									
1	7	19	6	0	14	4	.05	.001	.05
2	4	19	7	1	15	4	NS	.001	NS
3	2	24	9	0	12	3	.01	.001	NS
4	3	15	9	3	17	3	NS	.001	NS
5	2	16	11	4	14	3	NS	.001	.05
6	7	19	13	6	3	2	.001	NS	.05
Expected Frequency	TR 12		TL 12	BR 12		BL 12	T/B	R/L	Interaction
Test Trials									
1	11		23	6		8	.01	.05	NS
2	10		19	10		9	NS	NS	NS
3	10		21	7		10	.05	.05	.05
4	15		17	9		7	.05	NS	NS
5	12		21	11		4	.01	NS	.02
6	11		22	3		12	.01	.01	NS

For three of the six practice trials the top position was fixated first more frequently than expected by chance, the level of significance reaching .05 on one trial, .01 on another and .001 on the third. The bottom position was not fixated more often than expected by chance for the three remaining trials. For five trials the middle position was fixated more often than expected by chance at the .001 level and on one trial there was no significant difference between the left, right and middle positions. On one trial the bottom right position was completely ignored and on two trials the top left position was fixated more often than expected by chance at the p = .05 level.

The fact that the top positions tended to be favoured over the bottom positions, even though the lights were arranged in such a way that the bottom pictures were better illuminated, argues against the idea that the ability of Ss to direct their EMs to the bottom positions when so directed in the Top/Bottom studies was due to the confounding factor of degree of illumination. It is interesting to note however that when the S first fixates a more extreme picture than the middle one that the top/bottom differences appear. Although the top middle position is fixated more often that the bottom middle position on five trials these differences are quite small.

8.8. Discussion of Factors Affecting the Judgement of Negative Quantifiers by Pre-school Children. In order to begin to explore the reasons for the poor performance of the pre-school children in judging the negative quantifier sentences appropriately, as compared with the relatively competent performance of the Ss in Donaldson's study, consideration will be given to the ways in which a subject might encode true and false non-binary negative sentences as well as the arrays against which they are judged. The possibilities for encoding sentences and arrays in binary as opposed to non-binary situations will be discussed with reference to the ease with which each sort of encoding could be used in the comparison process leading to a judgement. The discussion will roughly follow the outline of the Clark and Trabasso type of model of sentence verification, since it would seem, in terms of the search strategies employed, that younger Ss attempt to describe an array however inadequately, without precise reference to the sentence and that only the adults use the sentence to guide their search of the array. Throughout the discussion reference will be made to Table 9.8 which provides examples of the way arrays and true and false negative sentences can be encoded, both in a binary and in a non-binary situation.

While the sentence to be judged probably constrains the pre-school child's search and description of the array in some respects, such as requiring the child to note the identities of shapes rather than colours, the constraint of quantification is pretty loose. If it is assumed that children prefer to encode arrays in a positive way, as seems likely from the reasons given for their judgements, then it is not unreasonable to suggest that the child will attempt to recode a negative sentence into a positive form so as to most easily match the two encodings. Of course if the array description is encoded in a negative form then it can be directly compared to the negative sentence without any sentence recoding.

With binary sentences and situations it is possible to recode a negative sentence into two kinds of positive encodings with the A form involving a change of predicate so as to include an implicit negative but maintaining the truth value of the sentence whereas the B form maintains the predicate of the sentence but changes the truth value. Thus, in Donaldson's experimental situation, if the child has encoded an array as 'True (all the lights are off)' and he then has to verify

'None of the lights is on' he may convert the sentence into the A form 'True (all the lights are off)' or the B form 'False (all/some of the lights are on)'. Then if the child choses an A recoding, a match is readily ascertained between the array and sentence representation since both truth values and predicates match. If a B encoding is chosen then a comparison with the array coding leads to two mismatches and a final correct judgement of true. With a binary situation and a false negative sentence, the sentence recoding can again take two forms, but in this case each results in one mismatch and thus gives an appropriate false judgement. Donaldson reports that her Ss seemed quite competent at recoding binary negatives into their positive equivalents, which may be why they performed so well. Where a non-binary situation exists, the likelihood of the young Ss recoding a negative sentence into either the A or B form with equal facility seems very much reduced. This is because recoding a negative non-binary sentence into a positive A form requires the ability to calculate the widest range of possible alternatives to the situation of 'not X', to subsume these alternatives under a general classification and to use this term in the changed predicate. Thus, it would seem unlikely that many young children would be able to produce the non-binary A recodings given in Table 9.8. Rather the B recoding seems the most likely form to be generated and providing that the truth value is changed the comparison with the array encoding should lead to two mismatches and a true judgement for true sentences, and one mismatch and a false judgement for false sentences. But it seems that this is just what the young Ss fail to do since by neglecting

Table 8.10 Combinations of Sentence and Array Codings and Recodings

Negative Sentence Types	Sentence Examples	Positive Recodings of Sentences		Array Codings	
		A(Recodings (same sign as sentence)	B Recodings(same predicate as sentence)	Positive Coding	Negative Coding
BINARY TRUE	None of the lights is on	T (All of the lights are off/not on	F (All/any of the lights are on)	All the lights are off	None of the lights is on
BINARY FALSE	None of the lights is on	F(All of the lights are off)	T (All/any of the lights are on)	All/some of the lights are on	None of the lights is off None of the lights are off
NON-BINARY TRUE	None of the ladies has a dog	T(All the ladies have something other than a dog/or nothing)	F(Any of the ladies has a dog)	All the ladies have nothing/something other than a dog.	None of the ladies has a dog.
NON-BINARY TRUE	None of the pictures is a star	T(All the pictures are things other than stars)	F(Any of the pictures is a star)	All the pictures are other things There is a......	None of the pictures is a star
NON-BINARY FALSE	None of the ladies has a dog	F(All the ladies have something other than a dog)	T(All/some of the ladies has a dog)	All the ladies have a dog	None of the ladies do not have a dog
NON-BINARY FALSE	None of the pictures is a star	F(All of the pictures are other than stars)	T(All/Some of the pictures are stars)	All the pictures are stars	None of the pictures is not a star

to reverse and remember the false truth value, a reverse pattern of judgements emerges which is the same as that observed for so many Ss. Alternatively, the S may not simply fail to reverse or remember the truth value but may encode "all or some" as a straight translation of "none". Thus one subject justified his true judgement of "No lady has a dog" (NF2+/2) with the reason "because you thought every lady has a dog". Other Ss would say it was true "because there <u>are</u> two dogs" but it was difficult to tell if the S was stressing an assertion of their interpretation of the sentence or denying the statement although this was not reflected in their judgements.

With age these difficulties of sentence processing may be overcome either by learning to encode the array in a negative form and to compare the sentence directly, or learning to make A encodings on the basis of experience with the types of alternatives presented or else by learning to encode and maintain the changed truth index on B encodings.

An alternative explanation of the reversal pattern of response might be framed in terms of the young S taking any change between the SE array and the test array as making the sentence true and no change as making the sentence false. This would correspond to the idea of negatives signalling a change of meaning. However this would not account for the reversal errors made in the studies which will be reported in the next chapter. Further attempts to delineate the factors affecting the young children's performance with negatives will be left until these studies have been presented.

8.9. Summary. The various factors affecting the Ss' performance were examined with a view to seeing if the choice of search strategies, as determined by the Ss' understanding of the sentence to be verified, could adequately account for the differences observed in terms of the RT and EM measures.

With respect to Group 1 Ss, who made the same sort of search whether an affirmative or negative sentence was to be verified and whether or not a true or false judgement was to be made, no differences in RTs or EMs were found between affirmative and negative, nor between true and false trials. Thus there was no evidence to suggest that pre-school children were able to recognise when negative quantifiers were to be reckoned with, and then, because of difficulty in dealing with them found it necessary to revert to treating them as affirmatives. For most of these Ss, the negatives did not even seem to be recognised as having a different meaning from affirmatives.

For Group 2 Ss there was some evidence to suggest that difficulties were experienced in the processing of negative quantifiers rather than in the selection of information on which to base a judgement. This was because longer was taken to verify negative quantifiers than affirmative ones, even though exhaustive searches tended to be carried out for both sorts of trials. It was also the case that for both true and false trials exhaustive searches were made but here no differences were found in terms of RTs or EMs so that there was no evidence of additional processing difficulty being experienced with false trials.

For adults no significant differences were found between either the RT or EM measures taken on negative trials and those taken on affirmative trials and no differences were observed between the kinds of search strategies. However there is some evidence for false trials being found more difficult at a central level since no differences were found between RT and EM measures on false or true trials and yet more selective searches were made on false trials. Either the time saved by not inspecting each of the pictures once was spent on viewing some of the pictures more often or more time was spent on the actual processing.

The growth of the ability to make efficient searches would seem to play an important part in being able to judge quantifiers more efficiently in terms of RTs or EMs, although this is not to deny that development, in terms of the processing of information once it has been appropriately selected, must also be taken into account, especially in the case of the Group 1 Ss who were generally unable to deal with relevant information even when it had been located.

The findings generally support Vurpillot's (1968) conclusion that with age perception comes to be subordinated to intelligence. Her description of the stages involved in this development were largely substantiated inasmuch as the pre-school children who had no definite criteria on which to make a judgement also scanned the pictures at random and even when the children at school age did adopt a consistent criterion for their judgement, this did not automatically lead to an efficient search strategy. Only adults were observed to adopt both appropriate criteria and efficient search strategies.

However, unlike Vurpillot, the present study did not find that children after the age of about 6 years appreciated that a single difference between two compared objects constituted sufficient evidence to allow for a 'false' or 'different' judgement. Vurpillot had found that children more than 6 years old made more paired comparisons when identical pairs of houses were presented than when non-identical pairs were presented, whereas the results of the present study indicated that up till the age of 10 years children made as great a search of the visual array for 'false' sentences as for 'true' ones. Perhaps this discrepancy in results can be attributed to the fact that in Vurpillot's task the comparison was made between two perceptual arrays which were immediately available to the S, whereas in this study the S had to compare a mental representation derived from the sentence against the available array. This quite possibly consituted a more difficult task.

It only remains to ask what sorts of factors determine the selection of the search strategies. For the adults, a comprehension of the logical constraints of the task seems to be of prime consideration although even adults do not often recognise the force of the single falsifying instance. For the older children there seems to be some awareness of the logical constraints of the task, but only in terms of what is necessary information and not in terms of what is sufficient information. The task constrains the school-age S to try to represent the array fully but not to search it selectively. It would seem that the S of this age chooses to arrive at his correct judgement by fully coding the array and then comparing this description against the sentence description. This is probably why this group showed the largest difference between the judgement times for affirmative and negative trials as would be predicted by the 'true' model of sentence/picture verification processing. This model, however, does not predict the performance of the adult Ss, who were more able to use the sentence to anticipate what would constitute verifying or falsifying evidence and did not so often seek to generate a full description of the arrays on false trials. For Group 1 Ss logical constraints did not determine the search strategies even when the correct response was given, but the sentence did constrain the Ss to attempt to find at least one instance of the pictures mentioned in the sentence in the specified relationship.

CHAPTER 9

Two Studies of Factors Affecting Negative Sentence Verification

9.1 Introduction. Donaldson's study (1972) leads to a higher estimation of the ability of pre-school children to judge negatively quantified sentences than would be warranted on the basis of the experiment just reported. She found only 22% of negatively quantified sentences were inappropriately judged with extremely few systematic errors, whereas 58% of such sentences were inappropriately judged in the eye movement study, with systematic 'reversal' errors accounting for 70.6% of the errors.

The two experiments were compared with a view to ascertaining if the differences in results could be attributed to any differences in experimental procedure or in the types of arrays and sentences used for comparison. The most likely candidates as factors likely to hinder or facilitate performance were the following: whether or not the sentences and arrays were to be encoded in a binary way which would allow for subsequent recording; whether the array or the sentence was presented for encoding first; and whether the array was presented in the state in which it was to be encoded (static presentation - SP) or changed into that state in front of the child (dynamic presentation - DP). In Donaldson's study the experimental situations were binary with the arrays being presented, and often changed into the state to be encoded, before the sentences were presented. In the eye movement study the experimental situations were not binary and the arrays were presented in a static way after the sentence had been presented first.

In the first study to be presented, the effect of the type and order of array presentation on the verification of negative binary sentences by pre-school children was investigated. Included in the second study was a consideration of the ability of young children to verify very simple non-binary negatives when the array was presented second. This was carried out as part of a larger study which was concerned with the question of whether pre-school children could use negative information to guide opposing search strategies, depending upon whether the task is a 'find' or a 'verify' one.

On the basis of preliminary pilot work it was decided to use very simple situations for both these studies, so that difficulties arising for the child from quantification or the universality of that quantification would not be at issue. Thus in the first study the child was required to recognize a model door as being open or not open, and in the second study he was required to recognize the identity of pictures of well-known objects.

9.2 Study 1. The Effect of Type and Order of Array Presentation in a Binary Sentence Verification Task.

Task: The task for the S was to judge, under 2 experimental conditions, each of four sentences made by the E about a visual array, which consisted of a red paper 'door' stuck onto a 3.5" x 3.5" white card. This door could be opened and closed by turning a paper clip. There were two kinds of sentences, namely "the door is open" and "the door is not open" which were each to be judged against the visual array in both its 'open' and 'closed' state. Thus under each experimental condition each subject experienced four trials, which when performed correctly gave rise to two 'true' judgements, one for a positive (TP) sentence and one for a negative (TN) sentence, and two 'false' judgements, one for a positive (FP) sentence and one for a negative (FN) sentence.

Experimental Design: The four trials could be experienced under two of four experimental conditions by any one subject. These conditions varied in terms of the type of array used, either static (A_S) or dynamic (A_D), and the order in which the array and sentence were presented. The four conditions, labelled A, B, C and D were as follows:

A) $A_D - S$ Dynamic presentation of the array before the sentence

B) $A_S - S$ Static presentation of the array before the sentence

C) $S - A_D$ Sentence presentation before the dynamic presentation of the array

D) $S - A_S$ Sentence presentation before the static presentation of the array

Four groups of S_S each experienced the trials under one of these conditions and then again under the condition representing the reverse order.

The assignment of conditions to the four groups of Ss was as follows:

Group	1st Four Trials	2nd Four Trials
	Conditions	Conditions
1	A (A_D - S)	C (S - A_D)
2	B (A_S - S)	D (S - A_S)
3	C (S - A_D)	A (A_D - S)
4	D (S - A_S)	B (A_S - S)

Thus groups 1 and 3 were used to look at the effect of order on dynamic arrays and groups 2 and 4 to look at the effect of order of presentation on static arrays. The order of trials was counterbalanced within groups but remained the same for each S across both groups of trials.

Subjects: The number and ages of the SS composing the groups is given below

Groups	Number Ss	Mean Age	Range of Ages
1	15	4;4	3;8 - 4;8
2	15	4;5	3;8 - 4;11
3	14	4;3	3;6 - 4;9
4	14	4;2	3;9 - 4;9

Each group consisted of approximately half male and half female Ss. The Ss were selected and trained to judge simple affirmative sentences in the same manner and to the same criterion as in all the previous verification studies.

Protocol: The E showed the S the door and opened and closed it in front of the S, saying "I'm going to tell you something about the door. You listen carefully and look and see if I am right or wrong. Press the bell to tell me when I'm right and press the buzzer to tell me when I'm wrong; Listening?... 'I think the door is open/not open'." When S had signalled his judgement E asked "why was I right/wrong?". In the dynamic array presentations the door was introduced to the S and changed in front of the S into the state in which it was to be judged, with the E saying "See" to draw S's attention to the door. In the static array presentations the array remained in the state in which it was presented. In the 'sentence first' presentations the E repeated the sentence twice before introducing the door from a position out of the child's view. In the 'array first' presentations the array was presented, the child's attention drawn to it and then the E made the statement twice. A brief break was given after the first four trials.

The S's judgement and reason, if any, was noted for each trial.

Scoring: The number of errors made by each S under each condition was noted and scored as to whether they constituted a 'reversal' (R) error (when both true and false judgements made on the same kind of sentence were made inappropriately) or whether they were errors on true sentences or errors on false sentences. The number and kind of errors made by each group under both conditions were calculated and comparisons made between groups and conditions for true and false trials for both affirmative and negative sentences.

Results: True and false judgements of affirmative sentences under all conditions were made appropriately on nearly all occasions by all groups. Therefore the results will be concerned with the pattern of errors made on the trials where the negative sentence "the door is not open" was judged. Table 9.1 gives the proportions of errors and kinds of errors made by the four groups under the various conditions they experienced.

Table 9.1

Number (No) and Kind of Errors (Kind) made by Each Group under the First and Second Presentations of the Various Conditions of Array (A_D or A_S) or Sentence (S_D or S_S) First.

	G1		G2		G3		G4	
1st Pres.	A_D - S		A_S - S		S - A_D		S - A_S	
	No.	Kind	No.	Kind	No.	Kind	No.	Kind
	10/30	4R 1TN 1FN	12/28	4R 1FN 3TN	14/30	6R 2TN	12/28	5R 2FN
2nd Pres.	S - A_D		S - A_S		A_D - S		A_S - S	
	11/30	4R 1TN 2FN	10/28	3R 2FN 2TN	16/30	7R 1FN 1TN	14/28	6R 2FN
TOTAL ACROSS PRESENT-ATIONS	21/60	8R 2TN 3FN	22/56	7R 5TN 3FN	30/60	13R 3TN 1FN	26/56	11R 4FN

A Chi-square test was used to compare the number of errors and the number of reversal errors between groups. No significant differences were found between the Ss' performances under any of the conditions.

When the number of errors and of reversal errors is compared across groups but between conditions, the picture shown in Table 9.2 emerges. By inspection there is no difference between the Ss performance under any of the conditions.

Table 9.2

Number and Kinds of Errors made under each Condition

Order of Presentation of Condition	Conditions							
	A_D - S		A_S - S		S - A_D		S - A_S	
	No.	Kind	No.	Kind	No.	Kind	No.	Kind
1st	10	4R-1TN-1FN	12	4R-3TN-1FN	14	6R-2TN	12	5R-0-FN
2nd	16	7R-1TN-1FN	14	6R-0-2FN	11	4R-0-2FN	10	3R-2TN-2FN
TOTAL ACROSS BOTH ORDERS OF PRESENT-ATION	26/60	11R-2TN-2FN	26/56	10R-3TN-3FN	25/60	10R-2TN-2FN	22/56	8R-2TN-4FN

From Table 9.3 it can be seen that there is little difference between trials involving a dynamic array presentation and all those involving a static array presentation; all trials where an "array first" versus a "statement first" presentation was involved; and between all trials presented in the first presented con-condition versus those in the second presented condition.

Table 9.3

Number and Kinds of Errors for Three Comparisons

Comparisons	Number of Errors	Kind of Errors
1) Dynamic Arrays	51/120	21R-5TN-4FN
Static Arrays	48/116	18R-5TN-7FN
2) Array 1st	52/116	21R-5TN-5FN
Sentence 1st	47/116	18R-5TN-6FN
3) 1st presented condition	48/116	19R-6TN-4FN
2nd presented condition	51/116	20R-4TN-7FN

Thus, even though the number of errors of judgement made by pre-school children on negative sentences constituted 42.7% of all negative judgements and 76.8% of all errors were of the reversal kind, none of the experimental variables seemed to have any differential effect on the Ss performance. The percentage of errors found was almost twice that found in Donaldson's study even though the situation was in fact a simpler one. There are several reasons why subjects might have these errors. One may be that Ss encode an array in terms of 'shut' but do not appreciate the equivalence of 'shut' and 'not open'. However, this would apply only to true negative situations where the door was not open, and would not account for the reversal pattern of errors. It is possible that the errors made on false negative sentences were the result of the "yes-we-have-no-bananas-today" syndrome so that two different processes were leading to the reversal errors. The syndrome refers to the errors that might arise from the ambiguity of using 'yes' to deny a false negative sentence as in "yes, it <u>is</u>, the case that x is so' and then taking 'yes' to indicate 'right', resulting in a false negative error. Donaldson (1972) suggests that the positive force of the word 'yes' may be particularly powerful if the child is confused by the ambiguity of his statement which was originally a denial. It is also true that negatives can be used ambiguously and may be used to affirm a true negative sentence as in "no, it is not the case that x", so that if 'no' has any negative force and the child is confused by his judgement and his own description of the array then 'no' may be taken to indicate 'wrong'. These ambiguities of usage may by themselves lead to a 'reversal' pattern of errors for some Ss.

Yet other Ss may attempt to code the true and false negative sentences into the B coding form as proposed in Chapter 8, but may forget to change the truth value index. For other subjects the negative term may be empty of meaning or disregarded if the task becomes too complex for the S, even though the Ss may produce a negative term themselves in the reasons for their judgements. This seemed to be the case with one S who said "the door is not open" was correct of an array of an open door, because "it's open and you said it wasn't open", and with another S who said "the door was not open" was wrong of an array of a closed door, because "you said the door was not open and it's not". Since various models of processing or combinations of ways of processing the sentences could result in the patterns of errors observed, it is impossible to definitely ascribe the faulty performance of the younger children to any one factor.

However, the kinds of reasons given for correct and incorrect judgements reveal some interesting aspects of the Ss' performance. Table 9.4 lists the number of various kinds of reasons made for judgements of true and false negative sentences.

It can be seen that four subjects in all gave inappropriate descriptions of the arrays in front of them. These subjects seems to judge the array rather than the sentences. For false negative sentences an equal number of subjects giving correct and incorrect judgements, gave reasons in terms of a positive description of the array. Similarly for

Table 9.4. Nature of Justifications made for Correct and Incorrect Judgements

Correct Judgements		Incorrect Judgements	
False Negative Sentences			
Wrong		Right	
Number		Number	
48	'cos it's open	43	'cos it's open
1	'cos it's open & not shut		
9	you said it's not open and it is open	1	'cos it's open and you said it wasn't open
1	you said it's not open	1	'cos you said the door is not opened
1	you picked the wrong one	1	'cos you came out your door and you never locked it
3	'cos its not open		
True Negative Sentences			
Right		Wrong	
22	'cos it's shut(19)/ closed(3)	24	'cos it's shut(21/ closed(2)/locked(1)
21	it's not open (including one reinforced by it's shut	11	it's not open
1	cos it wasn't	3	no, it isn't
5	cos you said it's not open and it's shut/ closed/not open	1	cos you said the door was not open and it's not
1	cos you said it's not open and it is	1?	cos it's open
2	cos you picked up the right one		
1	cos there's that (clip) to keep it from going out		
TOTAL NO. REASONS	= 116/133		= 88/99

true negative sentences a majority of reasons for both correct and incorrect judgements were given in terms of a positive description of the array. One of the main differences between reasons for correct judgements and reasons for incorrect judgements was the number of 'correct' reasons which explicitly contrasted the sentence and the array or explicitly described the true negative arrays in a negative way, thereby overcoming many of the problems which may arise in recoding the sentence so as to match the positive array coding. However, apart from this difference, the reasons provided no way of distinguishing between correct and incorrect judgements. One can only conclude with Donaldson (1972) that "it seems at any rate to be true of young children that when the statement contains a negative there is a greater gulf of some kind between a correct 'reading' of the situation and a final correct judgement than where no negative is present.."

9.3. Study 2. Search Strategies in Verification and Finding Tasks.

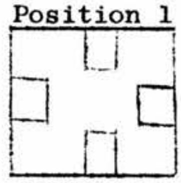
Introduction: This experiment was constructed with two aims in mind. The first was to compare the search strategies employed when the pre-school S was asked to operate according to the constraints of a "find" or "verification" task, using information from either affirmative or negative sentences. The second purpose was to look at the judgements of Ss when asked to verify affirmative and negative sentences which were not of a binary nature as was the case in the first study. Thus if the binary nature of Donaldson's (1972) experimental situations made them easier for her groups of subjects to judge than non-binary situations were for the subjects in the quantifier study, and since the subjects in study one made quite a few errors on binary situations, then one might expect an even greater number of errors to be made on the non-binary situations in this study. If at least the same frequency and pattern of errors as found in study one occurs, then it would seem that negation as such causes a great deal of difficulty for pre-school children in verification tasks and that not many pre-school children are as competent as those used in Donaldson's experiments.

<u>Experimental Tasks and Design</u>. Each S was presented with two tasks, each consisting of 4 practice trials and 8 test trials. On each trial the S was presented with a new sheet of paper (10" x 8") on which were pasted four pictures each covered by an opaque flap of paper 2" x 2", which could be lifted to make the picture beneath visible. The pictures were all clearly identifiable pictures of objects well-known to most children of the age group studied. The pictures and flaps were always located on the sheet in the manner shown in Diagram 9.1, 1 picture and flap being placed at the centre of each side of the sheet, at positions 1, 2, 3 and 4.

<u>Diagram 9.1</u>

Position 1

Position 4



Position 2

Position 3

Each sheet was clipped onto a board which was held upright in front of the S by the E, who sat to the right of half the children in each experimental group and to the left of the other half.

One task designated as the Find task required the S to use information from a sentence to find a specific picture. In the test trials there were four positive and four negative statements, two of each mentioning the top position and two mentioning the bottom position. The sentences took the form "The X(picture) is/is not at the top/bottom". For the affirmative sentences the picture was appropriately located so that it would be found once at each of the four positions. The four find practice trials simply required the S to find the specified picture without the aid of any information from the E. The picture was located so that it was to be found at each position once.

The other task, labelled the Verification task, required the S to verify a sentence made about the location of a specified picture. The same sentences were used as in the find task. The pictures were located so that two affirmative sentences were true, with one specified picture being appropriately located at the top and one at the bottom. The other two affirmative sentences were false since the specified pictures were not present at the specified position or anywhere on the sheet. The reverse situation obtained for the negative sentences where the pictures were not present for the true sentences and located at the top and bottom positions in order to obtain false judgements for the 'bottom' and 'top' sentences. The four practice trials for the verification task were all affirmative sentences, two referring to the top and two to the bottom location, one of each being true and one false. The designated pictures for the false statements were not present at any location.

In order to carry out the two tasks appropriately and efficiently, the subject had to utilize contrasting strategies when given a negative sentence to verify and when given negative information to use to find an object. The first task required him to look at the position which the statement had denied was the location of the object. The second task required him not to query the negative information given but to accept it and to ignore the location mentioned.

All subjects were asked to use only their preferred hand to lift the flaps, so as to allow the subject to make decisions upon successive rather than concurrent searches. The order of presentation of the tasks was counterbalanced across two groups of Ss so that Group A carried out the find and then the verification task and Group B received the tasks in the reverse order. Within each group the order of positive and negative and true and false trials was counterbalanced across 4 groups, each consisting of 5 subjects.

Subjects: Forty Ss were selected from local nurseries and trained in the same manner as in all the previous sentence verification experiments, except that Ss were only required to verbalize their responses and not to signal them by means of a bell and buzzer.

The Ss were divided equally into Group A and Group B with each group consisting of an equal number of males and females. The mean age for Group A was 4;4 years ranging from 3;10 to 5.0, while the mean age for Group B was 4:1 years ranging from 3;6 to 4;10.

Procedure: Before being given either task the S was presented with a sample array sheet, shown how the flaps or 'windows' could be lifted to reveal the pictures and asked to point to the top picture and the bottom picture.

For the practice find trials, the subject was shown a picture on a card, the E saying "See the X". This picture was then removed and the S instructed to "find the X as quickly as you can . It's hidden under one of the windows, tell me as soon as you have found it." He was then presented with the sheet and allowed to search for the object. For the test trials the S was told to listen carefully to the E. As in the practice trials he was shown an exact copy of the picture to be found and told "Now I want you to find X as quickly as you can. I'll help you to find the X. The X is/is not at the top/bottom". The last sentence was repeated while the test sheet was introduced and brought within range of the S who was then allowed to search for the picture.

For the practice and test verification trials the procedure was as follows. The S was reminded to listen to to the E who said "See the X", while showing the S a copy of the picture specified in the sentence to be verified. The picture was removed and the E said "I'm going to tell you something about the X and you have to find out if I'm wrong or if I'm right. You can only open one window to see if

I'm right or wrong". Then after pausing the E continued "I think the X is/is not at the top/bottom", You tell me if that's right or wrong". The sentence was repeated as the test sheet was brought within range of the subject who was allowed to select one window. If the child failed to make a response after looking at one window he was asked by the E "Was I right or wrong?". If the child attempted to open other flaps he was reminded that he could only open one window. In those cases where it was impossible to stop the S's determined search without sacrificing either the child or the test materials, the order of the windows selected in the continued search was noted, as was the judgement.

Scoring: Both the verification and find test trials were scored for each S for the appropriacy of the first position search. Each inappropriate first search was designated a Type I error. Verification test trials were scored for the number of trials on which redundant searches were made after the relevant position had been searched. These were termed Type II errors and represented those occasions on which the E was unable to get the S to stop searching and make a decision after searching the appropriate position. For Group A Ss the number of errors is an underestimation of the number of Ss who indicated some desire to search further. A third type of error, Type III, was scored on those negative find test trials when an inappropriate search was only made subsequent to an initial appropriate search.

The position first searched on each practice find trial was noted for each group so as to ascertain whether any response biases were operating when there were no specific linguistic constraints operating on the search. For both groups of Ss, the position of the first appropriate search made on each of the four negative find trials was noted. This was done so as to find out if the information 'not top' specified the'bottom' and 'not bottom' specified the 'top', rather than the positions 2 and 4. In other words, the problem was to find out if the S interpreted the task in a binary way, either when he had no experience of the chance of a picture appearing in a given position as for Group A Ss or when his prior task experience was of the pictures appearing only at the positions 1 and 3, as was the case for Group B Ss.

The verification test trials were scored for the appropriacy of the judgement made for each sentence type by each group, and it was also noted when a judgement was made on the basis of an inadequate search. It was possible for spuriously correct true and false judgements to be made depending on the Ss comprehension of the sentence and the information available from his search. The results were compared between groups and within groups for affirmative and negative, and true and false trials for each task.

Results: The kinds of search strategies carried out by Ss under different conditions will be the first aspect of the Ss performance to be considered. Table 9.5 gives the frequencies with which the four positions were first fixated on the find practice trials by Groups A and B.

Table 9.5. Frequencies of First Searches to Positions 1, 2, 3 and 4 by groups A, B and A & B Considered Together, with Chi-Square Values for Comparisons Between the Positions.

Groups	Positions				χ^2
	1	2	3	4	
A	30	16	17	17	6.7
B	25	21	14	20	3.1
A+B	55	37	31	37	9.8

Neither Group A nor Group B separately searched any position significantly more often than would be expected by chance, although the combined group frequencies showed a significant tendency (0.05 level) for Ss to search the top position first. Subjects showed a tendency to do this more often when they had no previous experience of the task or the possible locations of the specific picture.

Another finding relates to the question of whether the Ss treated negative find trials in a binary fashion, with a 'not X' instruction specifying one particular other location. Table 10.6 shows the frequency of appropriate first searches made to the three alternate locations remaining to be searched on a negative find trial.

Table 9.6. Frequency of First Searches to 'Binary' or 'Non-Binary' Alternative Locations

	Binary	Non-Binary		
	Top/Bottom	Left	Right	X^2
Group A	41	15	17	10.6
Group B	51	6	6	11.7

For both groups there was a significant (.001 level) tendency to first search the polar opposite term (the bottom position if the top was negated or the top if the bottom was negated), rather than positions 2 or 4. This tendency was especially marked for Group B Ss, who had previously experienced the verification trials when the mentioned picture was either at the top or at the bottom positions. Interestingly enough, although most Ss made some mention of the "top" or "bottom" very few Ss explicitly referred to the pictures at positions 2 and 4 by means of a spatial adjective. Most Ss referred to them, if at all, as "there" or "that window". Only a couple of Ss referred to them as "the sides" and none mentioned "left" or "right".

The number of type I and type II search errors made on verification trials and the number of type I and type III errors made on find trials have been summarized for each group and each kind of trial in Table 9.7.

Table 9.7. Summary of Search Errors

Total No. of search errors possible in each cell=40	Group A Verification (2nd Presented task)				Group B Verification (1st Presented task)			
	P		N		P		N	
	T	F	T	F	T	F	T	F
Search Error I	0	1	17	14	0	1	10	9
Search Error II	0	11	11	0	0	2	4	0
	Group A Find (1st Presented task)		Group B Find (2nd Presented task)					
	P	N	P	N				
Search Error I	3	3	0	0				
Search Error II	0	3	0	7				

Considering first the number of errors made on the find test trials, significantly (.05% level with Yates correction) more errors were made when the S had previously carried out the verification task and that more errors were made on the negative trials. The errors on the negative trials were made by 5 Group A and 8 Group B subjects. It would seem that a minority of the subjects continued to make the same search strategies than were required for the verification task.

To turn to the errors made by each group on the verification task it can be seen that only one type I error was made by each group on the positive trials. It was on the negative trials that nearly all the type I errors occurred, with little difference being evident between the true and false trials. What was noticeable was the greater number of type I errors made by Group A compared to Group B Ss, which was significant at the p = .01 level. When both type I and type II errors were considered together the groups differed significantly (at the p = .05 level). It seemed that the effect of initially ignoring the negated location in the find task carried over into the task where the S was required to attend to that location and that the subject was more likely to operate in terms of finding the specified picture, as indicated by the number of false trials on which unnecessary searches were made.

When the type II errors made on true negative and false affirmative trials were combined for each group, Group A Ss made significantly (at the p = .01 level) more errors than Group B Ss. The errors on true negative and false affirmative trials were combined because it is on both these trials that the specified picture was not present at the appropriate location. If a S was even partially using a strategy suitable for a find task it is on these trials that the S would need to make additional searches in an attempt to find the picture before verifying it. This may also represent an attempt by the subject to code the array in a positive form.

The appropriacy of the judgements made on the verification trials will now be considered with reference to Table 9.8 which gives the number of appropriate (A) and inappropriate (IA) judgements made on each kind of trial by both groups. All judgements were included whether or not they were based on a completely appropriate search.

Table 9.8. Summary of Judgement Errors

Judgements	Group B (Verification 1st)				Group A (Verification 2nd)			
	A		N		A		N	
	T	F	T	F	T	F	T	F
A	39	39	3	10	40	40	3	8
IA	1	1	37	30	0	0	37	32

True and false affirmative sentences were dealt with competently by nearly all Ss. However negative sentences occasioned an equal amount of difficulty for both groups, with true negatives proving more difficult than false negatives. A closer examination of the pattern of errors made by each subject reveals the following picture. For Group B, 67 errors (83.7% of judgements) were made in all. Of these, one was a spuriously correct false negative, six were errors made on true negative trials by four Ss, while the remainder, or 89.5% of the errors were composed of 30 pairs of 'reversal' errors wherein a S judged a true negative false and a false negative, true. Of these 30 reversal pairs, 28 were made by 14 Ss who each made two pairs of errors. Group A Ss made 69 errors (69.3% of judgements), including another spuriously correct false negative, seven true negative errors made on the basis of an inappropriate search yielding equivalent information, 4 true negative errors and 2 false negative errors, all six of which were based on appropriate searches. The remaining 56 errors (81% of errors) were composed of 28 pairs of 'reversal' errors, with 13 Ss each making two pairs of errors.

Across both groups only two children judged all four negative sentences correctly and two children judged one pair of true and false negative sentences correctly. Thus, it seems that children were fairly consistent in their errors. The reasons given for their errors suggest some interesting aspects of the child's reasoning, but there were insufficient reasons given for correct judgements to compare the reasons given for correct and incorrect judgements. Reasons for incorrect judgements most commonly gave a positive description of the location(s) searched although some reasons for incorrect true judgements stressed the absence of the specified object as in "wasn't there, no bananas", "it's not in all of these windows", "it's not on the page" and "it wasn't nowhere".

9.4. Conclusions: These two studies confirmed and extended the findings of the EM quantifier study, where 57.7% of negative sentence judgements were inappropriate and 73.7% of the errors were 'reversals'. The difficulty experienced by young children was not so marked in the situation where a simple binary negative statement was to be judged, but was nonetheless considerable, with 42.7% of negative judgements being erroneous and 77% of errors being 'reversals'. More difficulty than was found with either of these studies was experienced by children who had to search for the information on which to base their judgement about a simple non-binary negative statement. In this situation 85% of judgements were erroneous and 85% of errors were reversals. Only a few of these errors were due to inappropriate searches. Actually finding the information was not the major problem. What may have been a problem was remembering the negative aspect of the sentence until the relevant information had been found, although the time intervals would not have been greater than those involved in the EM study when the non-binary array was presented to subjects after the sentence. The studies did rule out certain aspects to which the difficulty in the judgement of quantified sentences may have been attributed, such as the problem of quantification itself, the negative idiom or the kind and order of presentation of the array. Although being able to recode the description of the array would seem to be important for the child in a verification task, some of the discrepancy between the results from Study 1 and those of Donaldson must be ascribed to the more advanced development of her subjects.

CHAPTER 10

Conclusions

The various studies presented here have been concerned to explicate the kinds of development which take place in the way children from preschool age onwards search the visual environment, with particular reference to the potentially directive role of language. Most of the studies sought to directly study the search strategies used in a sentence/picture verification task, but a few were concerned to tease out in a more direct fashion some of the factors apparently affecting performance on the sentence verification task.

One of these factors was the extent to which the child's understanding of certain concepts, as they were linguistically mediated to him or her, corresponded to the criteria normally accepted by adults as satisfactory or else the extent to which they corresponded to criteria accepted by logical standards. Thus it was found that preschool children were very poor at taking negative qualification into account when verifying sentences and children from six to eight years were particularly unwilling to accept and act upon a faced criterion of "in front of" and "behind" relationships rather than an "egocentric" relationship of these two spatial prepositions.

But over and above the actual form and content of the child's knowledge there was another factor which was found to be of importance in shaping the performance of the subjects at different age levels. This factor concerned the way the subject was able to use the information at his disposal to make fast, automatic inferences about what he expected to see and to alter his visual processes accordingly. In relation to transitivity and the development of logical mechanisms Bryant (1974, p.4) has argued that inductive inferences actively affect what children and adults perceive, saying that "one particularly attractive feature of this idea is that it suggests a connection between the way our immediate perception is organized and the way we organize our understanding of the world". These studies attempted to spell out what sort of connection this might be and how and at what rate it might develop by seeing if even young Ss were able to plan search patterns by inferring which locations would be relevant in situations which had some degree of meaning for them. As a generalization it seems reasonable to argue that until perception comes under the control of operational structures of intelligence it will be subordinated to objects which are temporally and spatially immediately present in the world, rather than subordinated to absent objects which can only be evoked by means of a symbolic process. In other words it is not until perception is cognitively controlled that a person can go beyond the available information to try to interpretatively reconstruct his expectations.

Certainly this view is supported by findings about the ability to direct eye movements only in accordance with information received linguistically about the world. It was only the teenage and adult groups in the Top/Bottom studies who searched the relevant location first even when there was nothing present there and other pictures were present elsewhere. This suggested that their search strategies had been previously organized and were executed independently of the perceptual arrays. The tendency for the younger subjects to make more eye movements when no picture at all was present in the array corresponds to Hornby's (1974) findings that more errors were made in a sentence verification task when the misrepresentation involved the presupposition than when it involved the focussed proposition.

Nonetheless it is important to recognize that the young child does show some small, nascent ability to organize search to a certain extent inasmuch as the appropriate location was searched first when no pictures were present at all. However, in other situations the ability to execute that search was affected by the visual field, with the presence of irrelevant pictures being more efficacious in "attracting" the gaze than was any cognitive plan in "projecting" it. Thus, children were distracted by irrelevant pictures before even finding the relevant picture although this grew less with increasing age. These findings complement those of other researchers such as Maccoby and Hagen (1965, Maccoby (1969) and Druker and Hagen (1969), who have argued that subjects from ten to thirteen years show a marked improvement in the ability to select what is relevant from what is irrelevant in perceptual and learning tasks.

What these studies do not take into account, and what the eye movement studies revealed, was a development and extension in the ways humans can and will normally interrogate and represent the world. This was suggested by the way, for younger subjects, sentences which were true of an array led to more efficient searches of the arrays than did sentences which were false. This aspect of efficient search became apparent, not so much from the way the subject directed his first eye movement, but from the extent to which additional eye movements were made after the relevant information had been located. The reaction time, number of eye movements and pattern data indicated that these searches represented systematic if inappropriate attempts to relate the sentence to the array and that they did not represent a non-specific concommitant of heightened attentive activity. The data from eye movement and other studies suggested that the young subject finds it difficult to interrogate and represent the world in terms of relationships, but rather prefers to maintain objects as "topics" about which different comments or relationships can be connected. Moreover the findings also confirmed that subjects expect to have their predictions about the world confirmed rather than disconfirmed.

Just as interesting as those aspects of the sentence verification task which showed development differences were those aspects which did not. There was firstly the tendency of even the youngest subjects to direct their gaze in the faced direction of the first fixated picture whenever certain kinds of relationships between two pictures were to be verified. This seemed to represent not so much an ability to deploy the gaze wherever it was deemed necessary by the task constraints, but to represent a presumably much over-learned habit to direct the gaze forward from an animate object or one capable of motion. This would seem reasonable in terms of the way most moving things act in and on the world. However this habit was only elicited when explicit instructions were given which enabled the subject to recognize that the pictures were to be related in some way. In order to get subjects to look to the unfaced side of the first fixated picture explicit "behind" instructions were needed and these were only useful when Ss accepted the relevant criterion of "behind".

One further aspect of the performance of the subjects indicated that the children matched sentences onto arrays in much the same order as did the adults. Adults as well as children made proportionately more fixations to verify passives than to verify active sentences, as though for both groups of subjects it was necessary to generate an array description where the order of the pictures would correspond to that of the sentence. The more efficient performance of the adults despite the additional number of fixations made compared to the children, was probably due to their ability to ignore irrelevant information once the relevant pictures had been located in their proper order.

It is hoped that while these studies have only filled a few of the gaps in our knowledge of the development of visual and linguistic processing, they will have provided a firmer foundation from which to build a more adequate theoretical and pragmatic view of the continual and mutually enriching interaction between language and vision. The fact that studying eye movements can be enlightening from a developmental viewpoint makes it even more pleasing to endorse Carpenter and Just's (1974, p.12) conclusions when they said:

"What is exciting about this eye movement research is that it is predicated on the hypothesis that eye fixations can be an externalization of the immediate processor. Eye fixations can be used to study what is being attended, encoded and how it is being operated upon in immediate memory .... Both the locus and duration of fixations reflect mental operations like encoding and comparing representations. Thus, this represents a way of studying extremely rapid mental operations in sentence comprehension".

For all this, it should be borne in mind that it is important to look at as many aspects of behaviour as possible so as to be aware of the ways in which Ss of different ages are able to compensate for difficulty experienced at one level by altering behaviour at some other stage of processing. Such information would lead to more hypotheses about the possible ways in which children progress from one stage of development to another. In the Quantifier Study it seemed that older children were able to make judgements on the basis of the relevant information but that in order to do this, more than sufficient information had to be examined. This finding qualifies the stand adopted by Piaget and various Russian researchers that the amount of perceptual activity diminishes with age. It is true that this can be seen from tasks where it is necessary for the subject to search selectively, but there is also a development with age in the ability to carry out extensive exhaustive searches when that is what is required. The most general characterization of the development of control over search strategies would have to be couched in terms of an increasing ability to recognize and carry out whatever sort of search is appropriate in a given context, whether it requires exploratory or whether it requires more selective performatory visual acts. This view would help to accommodate both the findings of Bruner and Mackworth and those of the present studies.

Mackworth and Bruner (1971) found that young subjects failed to select areas of pictures which adults found most useful for the visual comprehension of blurred pictures and suggested that this was because they were unable to synthesize degraded information coming from both central and peripheral vision at the same time. However these studies shows that when a few pictures were available and clearly focussed and the task was to relate only some of the pictures the problem of young subjects was not that relevant areas were overlooked because only a few areas of the array were inspected, but rather that the arrays were usually too thoroughly covered for the purpose of the task. It remains to be seen if this is also true of situations where even more irrelevant pictures were placed in closer proximity on the arrays.

A careful consideration of the kinds of visual searches made in response to a variety of sentences and arrays also points up several limitations to Vurpillot's claim that children are more limited in their visual searches and that this is due to their restricted ability to handle the information received during ongoing search. This may be true for some specific situations, but a more complete general characterization of young children's visual search behaviour would stress that it is because children do not have a clear idea of what to look for or do not use an idea to guide their searches that they either do not scan as widely and systematically as is necessary or else they scan more widely than is necessary for a particular situation. Whether or not the rate of scanning is then affected by the rate of processing must be considered independently.

Several incidental findings from the studies throw some light on assumptions, claims and suggestions made by other researchers. For instance, Charlesworth (1968) has argued against the Russian position that sufficient information for stimulus recognition could only be acquired through active scanning of all the stimulus parts. He has suggested that sufficient information might be extracted, even by infants by simply looking with a minimum of eye movements. He referred to a study by Nodine and Simmons (1972) when it was mentioned that several of their subjects, who were composed of children of six to eight years, were able to judge the similarity of two briefly presented letters by fixating a point midway between the two. Whatever may be the case with older children in a situation where the letters were quite close together, it was not the case in the studies reported here, that any of the Ss except for two adults, used peripheral vision to directly localize and organize elements of the stimulus array instead of using it to direct further eye movements. Thus when no stimulus picture was present in the relevant location all subjects, except for the two adults, failed to use that information to make a judgement without making any eye movements from H, even though that information must have been available to at least the younger subjects who acted upon it by ignoring that location.

Somewhat related to this point is the suggestion of Harris and MacFarlane (1974) that the use of enlarged stimulus arrays in order to study infants' visual preferences by observing their eye movements may have resulted in one stimulus being placed beyond the range of peripheral vision that would allow for re-orienting of the eyes. Accordingly, fixation would be artificially restricted to the first stimulus encountered, not because other stimuli are not attractive but because they have not been detected or else detection has not been able to overcome the inhibitions operating on re-orientations of the eye. Certainly this was not the case with the pre-school children, who were certainly able to detect (but not identify) and reorient the objects up to 30° on the periphery while fixating a central object. Indeed the reverse situation seemed to obtain, with the children seeking more information of peripheral stimuli than simply that of location and thus apparently being obliged to fixate more pictures than necessary.

Finally, the studies suggested that habitual motor patterns to look in certain directions rather than others, could be over-ridden under certain conditions by linguistic constraints operating on even the youngest subjects.

10.2. Directions for Further Research: With more sophisticated equipment, which would allow for the detection of far smaller eye movements and the measurement of the duration of eye fixations it should be possible to carefully study the development of the ability to both act and be acted upon by the visual world in static and dynamic situations. One could even take Cooper's (1974) experimental situation a step further to determine if the way the subject scans the world influences his own ongoing description of the world.

Using this sort of experimental setting the importance of presuppositions and expectations about the world could be examined developmentally, with particular reference to the way they are encoded linguistically. This could be done by varying the mode of address chosen by the speaker, the signalling of a certain topic of discourse, or the actual content of the message. The effect of violating certain kinds of expectations could be examined by means of visual responses to ambiguous or anomalous sentences. The feasability of such an approach was suggested by the results of one of the Top/Bottom studies which pertained to the reactions of the young subjects when no pictures were present. This seemed to represent a violation of their expectations that at least one picture would be present and the subject reacted by making many more fixations than on the other trials even though no pictures were present to be fixated. In this study it seemed that the expectation had been established by the prior introduction of the picture which was subsequently referred to with the definite article. It would be interesting to map out how various means of indicating the topic of discourse would influence the way subjects searched the world. In turn this would provide a way of confirming Tannenbaum and Williams' (1968) belief that focussing the subject's attention on one or another object in a picture resulted in the subject's taking less time to provide a description of that object in terms of whichever voice was appropriate depending on whether the object focussed upon, by means of a linguistic description, was the logical subject or logical object of the action represented in the picture.

Furthermore the development of specific spatial and temporal concepts could be investigated, especially in a dynamic situation, so as to determine when children become able to use such concepts to appropriately anticipate future events. In other words one can ask whether, even when people have good internal models against which to match the world, their control of visual processing is sufficiently organized to move ahead as well as being simultaneous with an ongoing cognitive task.

The development of the ability of young subjects to voluntarily direct or inhibit eye movements needs to be examined in various settings. A study of the effect of negative prohibition on looking as well as on more gross motor actions may reveal the extent of some of the limitations of conscious cognitive controls on the ocular motor apparatus. Lesevre's work suggests that the child cannot "voluntarily" move his eyes in a regular and pre-determined order over a display of spaced asterisks. However in the Quantifier study some school-age children gave evidence of being able to systematically scan arrays of up to six pictures. This suggested that it may be worthwhile to study the growth of the ability to direct eye movements in specific and sustained ways in the context of a wider range of tasks which would vary the degree of meaningfulness of the task for the child. It would also be of interest to look at the effect of repeated verbal instructions in aiding the child to maintain regular scanning patterns.

It only remains for the final obvious conclusions to be drawn in terms that will, by now, be familiar to the reader. These studies hopefully represent an "AFEM" in an attempt to test against the actual processes, our as yet poorly articulated hypotheses about the development of information selection, representation, and processing. Unfortunately the extent of our knowledge about what aspects of the child and the world affect the rate and sequence of development, is rather limited. For this reason the likelihood of making only efficient searches and of looking only at the necessary and sufficient aspects of development is small. The studies which have been reported should be regarded as a preliminary but necessary mapping out of some developmental factors which will require more scanning activity in order to establish the relationships between the factors. Nonetheless it is pleasing that overall the experimental search focussed on factors that proved to be relevant in ways that were both positive and negative.

Appendix 3.1. Test Sentences and Arrays used in 'Top'/'Bottom' Sentence Verification Task.

Sentences	Truth Value	Array Locations			
		A-top	B-bottom	C-left	D-right
1. The butterfly is at the top of the box	T	butter-fly	dog	basket	chair
2. The cat " " " "	F+	duck	star	tele-phone	parcel
3. The elephant " " " "	F-	-	cow	table	engine
4. The car is at the bottom of the box	T	horse	car	cowboy	teddy
5. The hen " " " "	F+	snail	lion	rabbit	indian
6. The man " " " "	F-	girl	-	bus	horse

Only A-location pictures were used in the 1-P Condition, A and B location pictures for the 2P Condition, and A,B,C and D pictures for the 4P Condition.

For the B2P Condition the pictures were arranged in the following way for the same sentences as are given above.

Array Location

	A	B
1.	butterfly	dog
2.	duck	cat
3.	-	elephant
4.	horse	car
5.	hen	lion
6.	man	-

Appendix 4.1. Sentences and Arrays Used for Active/ Passive Sentence Verification Task Requiring a Manual Response.

'Faced' Sentences	Truth Value True(T) or False(F)	Side for Appropriate Choice Left(L) or Right(R)
1) The cat is chasing a mouse	F	R
2) A hen is being watched by the lady	T	L
3) The policeman is chasing a dog	F	L
4) The horse is going after a milkman	T	R
5) A man is being waved to by the lady	F	R
6) An indian is being shot by the cowboy	F	L
7) The boy is following a cat	T	L
8) A lion is being watched by the man	T	R

'Behind' Sentences		
1) A baloon is being left behind by the boy	T	L
2) The boy is running away from a lion	F	L
3) A bus is being pulled by the engine	F	R
4) A man is leaving his bag behind	T	L
5) A dog has been left behind by the girl	F	L
6) The cat is running away from a duck	T	R
7) The dog is leaving his bone behind	F	R
8) A horse has been left behind by the cowboy	T	R

Appendix 4.2. Sentences and Arrays for Active Sentence Verification Experiment

		Array	TV	AFEM (Right /Left)
Group A	1. The lion is chasing a cat	←cat ←lion butterfly	T	L
	2. The horse is walking towards a lady	hen→ ←horse cake	F	L
	3. The boy is running away from a dog	man→ ←boy ←lady	F	R
	4. The man is looking at a motor car	bag man→ ←car	T	R
Group B	5. The boy is looking at a television	hen→ ←boy duck	F	L
	6. The cat is running away from a girl	girl→ cat→ policeman→	T	L
	7. The girl is chasing a horse	sol-dier girl→ man→	F	R
	8. The man is walking towards a tree	bear man→ tree	T	R
Binary Sentences	9. The lady is looking at a bucket	buc-ket lady→ flower	F	R
	10. The policeman is chasing a dog	car ←police-man ←dog	F	L

Appendix 5.1. Sentences and Arrays Used in the Active/ Passive EM Study

Faced Sentences	Voice: Active (A) or Passive(P)	Truth Value: True (T) or False(F)	Appropriate Direction of FEM: Right(R) v Left (L)
Group A			
1) The dog is following a lady	A	F	R
2) A cockerel is being watched by the lady	P	T	L
3) A lady is being shot at by the cowboy	P	F	L
4) The horse is chasing a girl	A	T	R
5) A man is being waved to by the lady	P	F	R
6) The policeman is chasing a dog	A	F	L
7) The girl is following a cat	A	T	L
8) A lady is being watched by the milkman	P	T	R
Group B			
1) A boy is being followed by the dog	P	T	R
2) The lady is watching a soldier	A	F	L
3) The cowboy is shooting an indian	A	T	L
4) A lion is being chased by the horse	P	F	R
5) The lady is waving to a girl	A	T	R
6) A duck is being chased by the policeman	P	T	L
7) A lion is being followed by the girl	P	F	L
8) The milkman is watching a boy	A	F	R
Behind Sentences			
1) The engine is pulling a bus	A	F	R
2) A car is being left behind by the man	P	F	L
3) A horse is being pulled by the engine	P	T	R
4) The man is leaving his bag behind	A	T	L

Appendix 5.1. continued.

Array for Group A and Group B

1)	X	dog →	boy →
2)	cockerel →	← lady	X
3)	indian →	← cowboy	X
4)	X	horse →	girl →
5)	X	lady →	← girl
6)	← duck	← policeman	X
7)	← cat	← girl	X
8)	X	milkman →	← lady
9)	X	← engine	← horse
10)	bag	man →	X

'X' refers to the irrelevant picture in each array, being different for each trial.

Appendix 6.1. Sentences and Arrays for 'In Front of' (IFO) and 'Behind' (BD) Sentence Verification Task

Practice Trials	Sentences	Arrays (as seen by S)
1	A cat is IFO the boy	← cat ← boy ←cat
2	A dog is IFO the hen	butterfly hen → snail →
3	A car is B the lion	car → lion → car→
4	A duck is B the horse	← boy ← horse ← girl
Directive Test Trials		
1	A lady is IFO the boy	umbrella boy → lady →
2	A horse is IFO the girl	← elephant ← girl ← horse
3	A dog is B the lady	dog → lady → TV –
4	A boy is B the cow	← boy ← cow – chair
Neutral Test Trials		
1	A cow is IFO a man	tree ← cow ← man
2	The girl is IFO a duck	car → girl → duck →
3	The horse is B a lion	hen → horse → lion →
4	The indian is B a cat	– horse ← indian ← cat

Appendix 6.2. 'In Front Of' and 'Behind' Instructions and Arrays

Presentation of SPs

Dimension	Axis	Orientation	Instructions
3D	B-A	Left	Put the y in front of the car
3D	B-A	Right	Put the y behind the duck
2D	B-A	Right	Put the y in front the the horse
2D	B-A	Left	Put the y behind the dog
3D	B-C	Face to S	Put the y in front of the cat
3D	B-C	Face to S	Put the y behind the boy
3D	B-C	Back to S	Put the y in front of the girl
3D	B-C	Back to S	Put the y behind the dog
2D	B-E	Face to S	Put the y in front of the boy
2D	B-E	Face to S	Put the y behind the girl
2D	B-E	Back to S	Put the y in front of the dog
2D	B-E	Back to S	Put the y behind the cat

Production Trials

← lion ← lady	When the lion is here, where is the lady?
elephant → man	When the elephant is here, where is the man?

Appendix 6.3. Experimental Trials Requiring FEMs in the Faced or unfaced Direction from the FFP

Sentence	Truth Value	AFEM for S (Left or Right)
Practice		
1) The milkman is walking to a lady	T	R
2) The girl is chasing a duck	F	R
3) The man is leaving a bag behind	BF	L
4) The boy is running away from a lady	T	L
Test		
1) The dog is chasing a boy	T	R
2) The lady is watching a soldier	F	L
3) The policeman is leaving his car behind	T	R
4) The girl is walking away from a tree	BR	L
5) The cowboy is shooting an Indian	T	L
6) The horse is chasing a soldier	BF	R
7) The cat is running away from a girl	T	L
8) The dog is running away from a lady	F	R

Appendix 7.1: Picture Descriptions and Amalgam Sentences used for Intransitive Test Trials in Experiments I and II

Pictures 1	Pictures 2	Amalgam Sentences A	Amalgam Sentences B
The curtain is torn	The man is running	The curtain is running	The man is torn
The man is frowning	The fire is burning	The man is burning	The fire is frowning
The boat is sinking	The girl is jumping	The boat is jumping	The girl is sinking
The man is waving	The chair is rocking	The man is rocking	The chair is waving
The top is spinning	The woman is praying	The top is praying	The woman is spinning
The snow is falling	The dog is barking	The snow is barking	The dog is falling
The boys are laughing	The bubbles are bursting	The boys are bursting	The bubbles are laughing
The wind is blowing	The cow is mooing	The wind is mooing	The cow is blowing
The boy is asleep	The cup is broken	The boy is broken	The cup is asleep
The mother is smiling	The tap is dripping	The mother is dripping	The tap is smiling
The cowboy is dead	The door is open	The cowboy is open	The door is dead
The lights are shining	The people are dancing	The lights are dancing	The people are shining
The ball is bouncing	The girl is crying	The ball is crying	The girl is bouncing
The butter is melting	The man is sneezing	The butter is sneezing	The man is melting
The coffee is spilling	The girl is skipping	The coffee is skipping	The girl is spilling
The plane is flying	The boy is swimming	The plane is swimming	The boy is flying
The baby is crawling	The telephone is ringing	The baby is ringing	The telephone is crawling
The water is boiling	The girl is roller-skating	The water is roller-skating	The girl is boiling

Appendix 7.2: Amalgam Sentences and Picture Descriptions for 18 Transitive Test Trials

Amalgam Sentences	Picture Descriptions: Subject Pictures	Verb Pictures	Object Pictures
Nonanomalous			
The mother is posting the book	The mother is cooking the porridge	The man is posting the parcel	The girl is reading the book
The boy is burning the pram	The boy is climbing the ladder	The fire is burning the house	The lady is pushing the pram
The boy is chasing the horse	The boy is beating the drum	The lady is chasing the dog	The girl is {clapping / patting} the horse
The teacher drops the flag	The teacher rings the bell	The girl drops the cup	The boy waves the flag
The boy is pulling the cradle	The boy is licking the ice cream	The horse is pulling the wagon	The mother is rocking the cradle
The sailor is tearing the letter	The sailor is winding the rope	The lady is tearing the cloth	The postman is bringing the letter
The father is punching the ball	The father is kissing the mummy	The boy is punching the cushion	The girl is bouncing the ball
The sailor is cutting the tablecloth	The sailor is tying the rope	The man is cutting the grass	The lady is shaking the tablecloth
The lady is kicking the baby	The lady is pouring the tea	The boy is kicking the dog	The girl is hugging the baby
Full Anomalous			
The tree is chewing the boots	The tree is losing its leaves	The dog is chewing his bone	The farmer is wearing his boots
The bird is milking the television	The bird is pulling the worm	The lady is milking the cow	The boy is watching the television
The waves are smoking the indian	The waves are rocking the boat	The man is smoking the pipe	The cowboy is shooting the indian
The cat is lighting the apples	The cat is scratching the door	The man is lighting the match	The boy is picking the apples
Semi-Anomalous			
The lady is riding the door	The lady is puching the pram	The boy is riding the bicycle	The man is painting the door
The cow is sweeping the box	The cow is eating the grass	The lady is sweeping the floor	The boy is carrying a box
The farmer is eating the car	The farmer is riding the horse	The girl is eating the sweetie	The lollipop man is stopping the car
The girl is feeding the piano	The girl is blowing the whistle	The mother is feeding the baby	The teacher is playing the piano
The boy is knitting the nest	The boy is drinking the milk	The lady is knitting the jumper	The bird is building the nest

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